JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] OCTOBER, 1868. [No. 4

EDITORIAL.

ITEMS AND NOVELTIES.

Soda Water Apparatus.—We spent an evening very pleasantly, some weeks since, at the Conversazione of the American Pharmaceutical Society, which was held in the new building of the College of Pharmacy in this city. Among the many pieces of apparatus and products of manufacture exhibited on that occasion, nothing will, we think, be of more interest to our readers, than the various machinery connected with the manufacture and storage of soda water (so called), or more strictly water holding in solution carbonic acid under pressure. The most complete collection of this apparatus, was that sent by Mr. John Matthews, of New York, and we shall proceed to describe some of the more prominent features and interesting novelties there represented.

When the father of Chemistry, Dr. Priestly, writing about 1772 (see his "Experiments on Different kinds of Air," Vol. I. p. 52), sug-

gested the application of water, charged with carbonic acid and with salts in solution, as a substitute for the natural waters of Pyrmont and Seltzer, and also the charging of wines with the same gas, he could certainly have little imagined to what this fertile idea would grow. Grow, however, it did, in all parts of the world, and in none more than our country, where, as an illustration, it has been computed that in New York alone, on a hot summer's day, more than one million of bottles of this material are consumed.

The forms of apparatus which are in use for the production of soda-water, may be divided into two classes, those in which the carbonic acid is first collected in a gas holder, and then by means

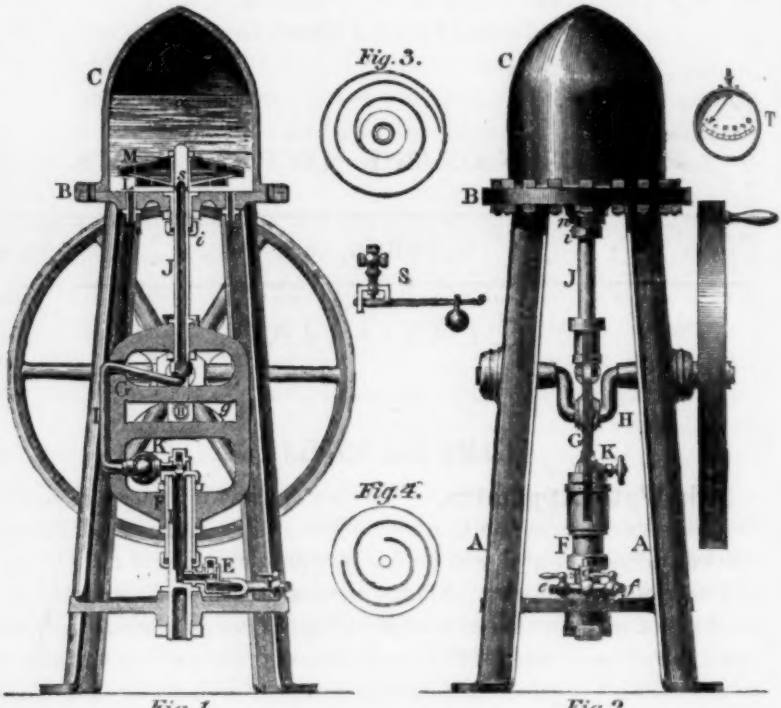


Fig. 1. *Fig. 2.*

of a pump forced into a strong vessel, in which it is absorbed by the water there placed; and those in which the gas is generated in strong vessels, in which it establishes a great pressure by its expansion in being evolved from the ingredients used, and then is simply allowed to flow into the charging vessel, where it comes into contact with the water and is absorbed by reason of the self-generated

pressure above mentioned. The first of these is the process generally followed abroad, while the second is that employed in this country. Mr. Matthews produces apparatus of both kinds, which we will describe in order.

In the first place, as regards that which may be called the European apparatus, and which in its original form, will be found very well described in the *Chimie Industriel*, of Payen, but which in the present case, has received many improvements, leading to increased strength, economy, durability, and the avoidance of leakage, as will be understood from the following description:—

In the accompanying engravings, Fig. 1 is a vertical section, and Fig. 2 is a perspective view of the apparatus, bearing at its top a table, B, on which is secured the condenser or reservoir, C, for holding the carbonic acid gas and water mixed therein, and which reservoir, by the present improvement, is made free from all joints below its water-line, the average level of which is indicated by *a* in Fig. 1. Inserted through the table, B, may be tubes, *m* and *n*, for attachment of the usual bottling-nipple, the pressure-guage, T, and safety-valve, S. Connected with the lower portion of the frame is a stationary hollow plunger, D, communicating below by a branch *b*, with a valve-box, E, the valve, *c*, of which is arranged to open upwards and control the suction by a passage, *d*, through branches, *e* and *f*, one serving as the induction-pipe for the water, and the other for the carbonic acid gas, which may be received from any suitable reservoirs. F is the working cylinder which plays up and down, over or outside of the stationary plunger, D, and is connected so as to be operated by a reciprocating yoke, G, which is driven by any suitable power through the crank, H, and having play in an oblong slot, *g*, of the yoke. The cylinder, F, is provided at its upper end with a delivery valve, *h*, which in the descent of the cylinder allows of the gas and water entering in at the up-stroke of the cylinder, through or beneath the valve, C, of the plunger, D, to be forcibly expelled through a branch, I, and vertical discharge-pipe, J, through perforations, S, into the reservoir, C. The plunger, D, and cylinder, F, act as a lower guide to this reciprocating arrangement, while the pipe, J, working through a stuffing-box, *i*, in the table, B, of the reservoir, operates as an upper guide.

K is a valve for shutting off communication between the pump and reservoir C, when necessary for repairs of the valves or other purpose, while the reservoir is full or under pressure. The gas and

water forced out through the perforations, S, during the action of the pump, are admitted to the reservoir, C; and to effect the mixture of the gas and water, two volutes, L and M, also shown in Figs. 3 and 4, are attached to the reciprocating discharge-pipe, J, where it projects within the reservoir, C, the volute, L, as it rises, causing the gas to work spirally outwards and passing up under the upper volute, M, which works in an opposite direction, and finally escapes by a central orifice. By means of these volutes, an effectual agitation of the water is kept up, and a thorough mixing of the gas with the water produced as they are worked up and down within the reservoir, C.

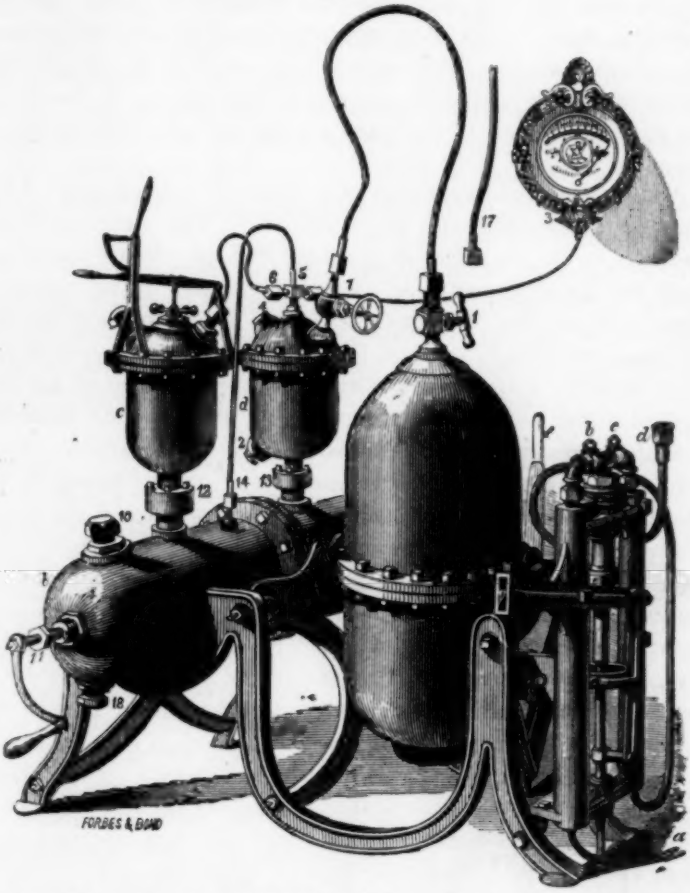
Among the advantages which are claimed for this improved apparatus, are dispensing with all joints above the water-level in the reservoir, C, the importance of which will be readily understood, when the great pressure of the gas contained in the reservoir is considered, and the difficulty that exists in making a joint, above the water-level, tight against the escape of gas; the pump, aided in its descent or discharging stroke by the pressure of the gas or gas and water, contained in the reservoir, acting on the head of the discharge-pipe; the pump is aided in producing further compression or condensation by the pressure previously effected by it, as where the pump is merely used to force in the water, the same, S, assisted in supplying the reservoir, C, by the pressure of the gas separately admitted. In addition to those advantages, is the great simplicity of the working parts and steadiness of the action as produced by the reciprocating cylinder, F, on the plunger, D, and discharge-pipe, J, through the bottom of the reservoir, the distance apart of the guides to the pump aiding in this result, and the reciprocating action of the pipe on the connection, J, in a longitudinal direction being preferable to a rotary one for working the agitator, as offering greater security against leakage at the stuffing-box.

The process which we may call the American method, is also illustrated by another of the forms of apparatus constructed and improved by Mr. Matthews, of which we have a very clear representation in Fig. 5.

The goblet-shaped vessel to the left of the cut is charged with sulphuric acid (commonly called oil of vitriol), which by means of a valve operated by the lever shown at the top, can be made to flow as required through the connecting neck, 12, into the large cylindrical vessel below.

In this vessel is previously placed (by means of the opening at 10 closed by a screw plug) a quantity of pulverized marble (carbonate of lime), or other alkaline carbonate, by reaction with which the sulphuric acid forms sulphate of lime, or of the other base, and

Fig. 5.



sets free the carbonic acid, before in combination. This carbonic acid gas then passes by the tube 14 into the second vessel, *d*, where it bubbles through a small quantity of water, by which it is washed clear of acid spray, or other impurity.

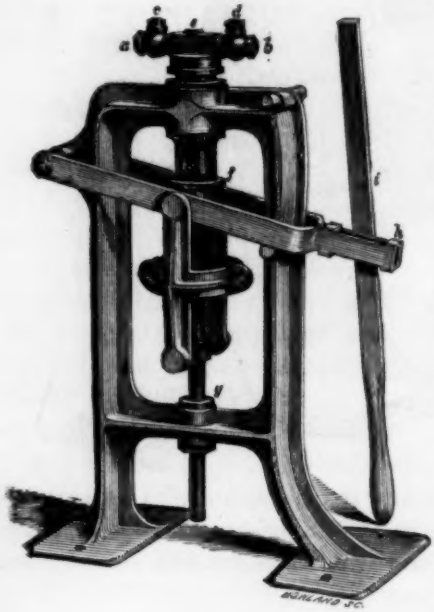
At the point 5, where the tube enters this vessel, two branches are taken off, one to the guage (3), which indicates the amount of pressure produced, and so prevents risk of accident, and the other,

c, to the sulphuric acid vessel, to establish an equilibrium of pressure, so that the acid may flow through the valve. From the washing vessel, *c* (which only rests on the cylinder, and has no communication with it at 13), the gas passes into the fountain or large eliptical vessel to the right, which has previously been filled two-thirds full of pure water, or with such a solution or liquid as it is desired to charge with gas, and is there absorbed by the fluid; this action being facilitated by a brisk rocking of the vessel on its trunnions, and consequent agitation of its contents.

To the extreme right, is seen a pump, by which water may be forced into the fountain even when it is under pressure, from a remaining quantity of charged water and gas, or by which gas may also be pumped when required.

These pumps, of which a more complete drawing is shown in Fig. 6, are of a very simple, enduring and efficient character, and beside their regular use, have been applied with great success in compressing oxygen and illuminating gases into iron reservoirs, for use in the production of the lime light.

Fig. 6.



Another of the ingenious contrivances which were exhibited by Mr. Matthews on the occasion above mentioned, was the arrangement of bottles for liquids under pressure.

Every one has remarked the great waste of corks which is constantly going on, and the constant depreciation of that material, (the result of an excessive demand,) causing great loss by leakage. This very serious difficulty has been met in the following way. A glass cork, with a head of india rubber, as shown in Fig. 7, is introduced into the bottle, which is then filled with the

soda water in an inverted position. The stopper thus lies with its glass point downward in the neck of the bottle, and as soon as the external pressure, by which the liquid is introduced, is withdrawn, the internal pressure forces the stopper out of the neck until it is arrested by the projecting rubber head, which makes tight joint in the neck of the bottle. When the bottle is to be opened, a smart blow upon the projecting stopper, (see Fig. 8), the bottle standing erect, drives it down inside, and the liquid may be *all* poured out, or its flow arrested, by inverting the bottle, when the stopper will again fall into place.

Fig. 8.

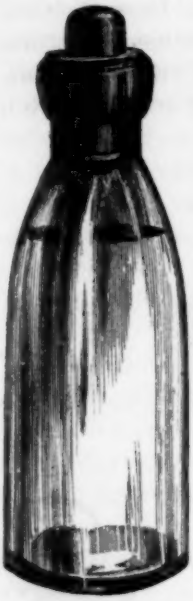


Fig. 7.

Our limits forbid us to say more, here, but in our next number, we will describe some other valuable improvements.

Centrifugal Pumps.—In a paper read at the late meeting of the British Association by Mr. Gwynne, on the above subject, it was stated that practice had shown that the most important requisites to secure a successful and economical result from the use of such apparatus, were the following: In the first place, uniformity of cross section in all passages and connections; and secondly, the avoidance of all sudden changes of direction. With regard to the first point it had been shown by experiment, that not only were contractions detrimental to the rapid discharge of a liquid through a pipe, as might be assumed naturally, but that enlargements were likewise prejudicial. Thus the investigations of Bossict had shown, that in a case where 4 cubic feet of water were discharged by a regular pipe in 109 seconds, when a tube of the same size, but with one enlargement was substituted, it required 147 seconds to discharge the same volume of water. With three enlargements, 192 seconds were required; and with five enlargements 240 seconds. This interference is undoubtedly due to the eddies and counter-currents as well as to changes in velocity which are induced by such irregularities.

The Geoselenean.—At the present day, when the range of our knowledge on all subjects is so rapidly increasing, anything which honestly facilitates the acquirement of information in those branches which are essential to a sound and liberal education, is of great value, because it renders possible the attainment of more than could otherwise be learned, and makes it possible for the general student

to keep up with the progress of the age. For this reason we are glad to draw attention to a new instrument, which is a modification of the well known Orrery devised by Mr. James G. Moore, and

embodying many features and the means of clearly illustrating many facts, not found in the old instrument.

This apparatus exhibits, by an absolute physical demonstration, many of those complete phenomena connected with the motion of the moon, earth and planets, which can thus be appreciated almost at a glance and adhere spontaneously in the memory, but which, without such aid, can hardly be grasped by ordinary minds, even with persistent effort, and are then likely to be as difficult to retain in the memory, as to secure.

The accompanying figure shows the general appearance of the apparatus, which it would be out of place for us to describe, since its essential feature is, as we have stated, the doing away with descriptions by exhibiting the very phenomena in question. (See advertisement on another page.)

Mr. Eads' Report on the Illinois and St. Louis Bridge.—(*ERRATA.*)—In the notice of this report, which appeared in our last issue, a strange mistake occurred, in a curious way. We marked on the margin of page 51, near the top, for insertion, the following:—

"Enough is known, however, to assure us that the limit of elasticity is higher in compression than in tension, and if it were no greater, we cannot avail ourselves of more than 50 or 60 per cent. of this limit in tension, while the whole of it can safely be utilized in compression." The ink, however, soaking through the leaf to the other side, caused a similar mark to appear upon another sentence exactly corresponding in position and length, and, moreover, in general style and wording, except that it conveyed an almost opposite idea. This side of the leaf was, by ill luck, copied in place of the other, and we are thus made to stultify our assertion by the quotation of what precisely *does not* prove it.

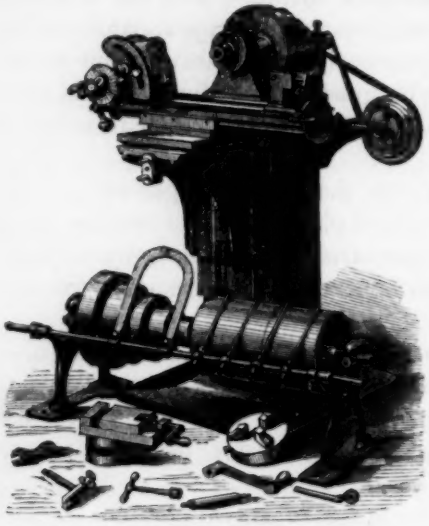
If our readers will, however, substitute the above quotation for the one found on page 150, our common sense will be vindicated.

We also observe that our compositor has thought good to insert an "s" in the word "decrying," and thus again invert our meaning. We *have* every wish to "descry" Mr. Eads' bridge spanning the Mississippi at an early date.

Universal Milling Machine of the Brown & Sharpe Manufacturing Co., Providence, R. I.

In the accompanying wood-cut, we illustrate this piece of apparatus, of which we have heard very favorable accounts from many

of our Philadelphia machinists who have it in use, among whom we may enumerate Messrs. Wm. Sellers & Co., Bement & Dougherty, Cresson & Smith, Morris, Tasker & Co., Henry Diston, and others.



This machine is adapted to the making of many tools required by gun makers and machinists, such as twist-drills, mills of all shapes, with straight or spiral teeth, and cutters for gear and other work. It will, moreover, cut a tapering or conical mill, with right or left hand spiral teeth, and will supply the place of the common index milling machine.

In the upper part of the cast iron frame is the main arbor, made of steel, with bearings, which may be adjusted to take up wear.

On the front of the frame slides a knee, controlled in vertical movement by a screw operated by a bevel gear and crank in front, and having also a stop-motion, which limits the rise and fall of the knee, and thus regulates the depth of the milling. On the top of the knee is a slide moving toward and from the main arbor, and on this is a rotating plate, with a graduated arc and means of clamping firmly to the slide.

In this also slides the long carriage, shown in position by the cut, which is operated by a long screw and handle at one end, which is also capable of being driven from the feed cone by a small shaft with two Hook's joints. By this means the carriage may be fed at any angle. At one end of the carriage, the right side of the cut, is a stand, sliding in a groove, with a centre in its top.

At the opposite end is seen a head, having a hollow arbor, in which a centre can be placed. Between this and the centre of the stand, the work to be milled is placed, and any spiral or the like can be made by means of the index on the side of the head, which is connected with the arbor by two mitre gears, a worm, and a worm wheel. The arbor in this head can also be connected with the screw that gives motion to the carriage.

The interior part of the head supporting the arbor can be raised and set to any angle, thus rendering the cutting of tapering spirals as easy as straight ones.

A small universal chuck (shown on the ground in the figure) is made to screw on the arbor, and is useful in cutting face mills or other like work.

Shaw's Lock-Nut Washer.—Among the many attempts to secure nuts upon bolts, one of those which combine simplicity and efficiency in an eminent degree, is that mentioned above. This device consists of an ordinary plain washer constructed of steel, cut through one side, and bent so as to represent one coil of a spiral, the flat edges of which come first in contact with the nut. These are made sharp, and the coil is in a direction that permits the nut to revolve over it when being made tight; but the edge of the washer catches into the nut when turned back, with sufficient power to prevent the nut from turning on its own account, though it yields to the force of a wrench.

The advantages claimed for this method of locking nuts are freedom from any ragged points to surround the nut; the rendering use of two nuts no longer necessary; the dispensing with pins and keys; and last, but not least, the doing away with destructive riveting of bolts, thus offering, in many cases, at once a better and a cheaper method. Those connected with railroads will be quick to perceive the advantage of this improvement as one compatible with safety and economy. Messrs. Furbush & Gage, Office 118 Market Street, Philadelphia; Manufactory, Camden, N. J., are the manufacturers of this article for railroads and other purposes, from whom any further information can be had.

Dynamite.—The wonderful results, as regards increase in progress and reduction of cost, which have been attained with Nitro-Glycerine make its employment in all extensive blasting operations of the greatest importance; but, at the same time, the terrible and in many cases inexplicable cases of explosion during or after transit which have occurred within a short time, do and ought to check this otherwise desirable application of a new agent whose power is unparalleled.

Under these circumstances, we read with pleasure, an account which was given before the British Association by Mr. Nobel, of a simple modification, or, rather mixture, of this substance, which seems likely to rob it of its dangerous, while leaving unimpaired all its useful, properties.

When nitro-glycerine is mixed with one-fourth of its bulk of porous silica, we are told that a soft solid, somewhat of the consistency of tempered clay, is produced, to which the name *dynamite* has been given. What this porous silica may be, we are not told, though it is evident that a mistake has been made in some foreign journals, where it is described as sand or gravel, 25 per cent. of which, added to such a liquid as nitro-glycerine, would certainly not bring it to the condition described. The great element of security which is introduced by this simple change of form, consists in the avoidance of leakage, which it appears in practice almost impossible to prevent, while the substance is in its fluid state, and which, by exposing this material in a shape most favorable to all decomposing actions, to the influences of the air, of heat, of percussion, and of friction, may be regarded as the primary cause of all the terribly destructive accidents which have occurred with this material.

This will explain the strange inconsistency which all have no doubt remarked between the reported properties of nitro-glycerine, as described by those most familiar with its manufacture and use, and the actual properties which it has occasionally exhibited. In fact the two classes of properties have belonged to different substances. The first being those of nitro-glycerine, the latter of some as yet unknown modification, induced by exposure to such influences as we have enumerated.

As for the safety of the explosive in its new form above described, the following experiments made at Glasgow, and repeated at Merstham, will say much. A box containing 8 lbs. of dynamite (equal in effect to 80 lbs. of powder,) was hurled down from a height of 60 feet upon the rock below. The box was broken by the fall, but its contents was not exploded. Another similar box was then placed on a fire, where it slowly burned away.

At Stockholm a yet more severe test was applied, for a weight of 200 lbs. was dropped, from a height of 20 feet, upon a box of dynamite, which it smashed without exploding.

While thus sluggish in its action, and, as it were, unwilling to be roused into a display of its force, its ability, when the proper stimulant to exertion has been applied, may be estimated from the following experiment:—

A cylinder of wrought iron was prepared, eleven inches in diameter and twelve inches long, with a hole one inch in diameter

along its axis. Six ounces of dynamite were introduced into this hole, without any tamping at either end, and fired by a fuse, when the cylinder was split into two pieces, which were violently hurled to a distance.

That such an explosive as nitro-glycerine should effect a great saving of cost as well as time, in all mining operations, will be evident if we reflect that cost of *introducing the explosive* by means of drilled holes is enormously greater than the cost of the explosive itself. When, therefore, we have, as in this case, a substance which in the same bulk concentrates a ten-fold effect, we see that the same amount of *expensive* labor will obtain a ten-fold result, while the increase in cost will be only in the *least expensive* item.

In fact, from a number of cases cited, it appears that about 25 per cent. of the entire cost of mining is saved by the use of this material, while the increase in the rate of progress sometimes amounts to 87 per cent., as in a long tunnel through Stockholm.

The importance of this saving in an extensive piece of tunneling requiring large capital, which earns nothing until the work is finished, is enormous, as we may see by considering the case of the Mt. Cenis or Hoosac tunnel.

The use of nitro-glycerine has been prohibited in Belgium and Sweden, but this regulation, it has been decided, does not apply to dynamite.

Watering Roads with Deliquescent Salts.—It is stated in our excellent cotemporary, *Engineering*, that this process has been attended with excellent success, in London, during the summer months. Along Baker St. Portman Square, where the experiment was tried, it had given the greatest satisfaction to all the residents; and even on Sundays, when all watering of streets was discontinued, this locality enjoyed a clear atmosphere, while the neighboring thoroughfares were clouded with dust.

Bleaching by Ozone.—Under the heading of "A Doubtful Electric Item," we find in *Engineering*, allusion made to a report, that works had been erected in London, where sugar was to be bleached by a current of electricity. From a gentleman interested in the subject of sugar refining, who has just returned from England, we learned the actual state of the case, namely, that works were erected to carry out the process much ventilated in the foreign journals about a year since, in which ozone was to be developed in large quantity by passing air over a series of plates electrically

charged, and then used as a bleaching agent. On the small scale, this process operated with marked effect, but when attempted on a commercial scale, failed entirely, for causes unknown, but such as rendered an adequate development of ozone impossible. A. Wilde's magneto electric machine was employed as a source of electric force.

Editorial Correspondence.

FIRE PROOF BUILDINGS.

NEW YORK, *September*, 1868.

FIRE proof construction has become a matter of such necessity, especially in our older cities, that it is interesting to note the improvements, from time to time instituted, and how they are carried out. Any method tending to cheapen such buildings, is an invitation to their still further introduction, and an invitation that many real estate owners would avail themselves of. Under the present method of design and execution in this city, fire proof building is such an extravagant luxury, that rarely any private party can indulge in it, leaving such desirable improvements in the hands of wealthy corporations. Of course such a mode of building always must be more costly than where timber is used; but there is no reason in the world why it should present such an item of expense as in the City of New York. As yet few, comparatively, have been built, but many more are wanted and would be built, could owners be brought to believe that the examples before them, and from which they naturally form their opinions, are monuments of a shameful and wicked extravagance.

Iron is a material of infinite service, when properly and intelligently used, but a very dangerous material in the hands of ignorance or dishonesty. Its nature is such that we can more nearly work to its theoretic limits than can be done with any other material of constructions. The specific gravity of iron is so high that all used over and above what is really required for performance of duty, rolls up very rapidly a very costly excess. It is of very recent date that solid rolled beams of wrought iron have been used

for floor joists, before which time cast iron beams had been largely used, especially in England. Many accidents proved their unreliability, and beams built of plates and angle irons were substituted. In this country, the Cooper Institute was the first thoroughly fire proof building ever built, the beams for which were rolled at Trenton. These beams were nine inches deep, and were rolled from a single "pile," and it seems were necessarily about the largest beams that could be made by that method of piling. Not long after, Mr. Jno. Griffin, of the Phœnix Iron Co., invented and patented a plan by which beams could be solidly rolled up to at least twenty inches deep, and as long as would, in any event, be required. Mr. Griffin's invention consisted in rolling flange-bars separately, piling the plates to form the web between them, and then rolling and welding the whole mass together. It may be interesting to note that this process was pirated by the English manufacturers, and is in vogue with them to this day. It is, perhaps, the only method by which beams of large sections can be successfully made. We believe, in Pittsburg, they profess to make their beam piles by placing channel bars back-to-back, and thicken up the flanges, when desired, by piling plates on the top and bottom. At present, rolled beams are manufactured in this country, at Phœnixville, Buffalo, Trenton and Pittsburg. The two former make beams under the Griffin Patent, running through a list of sizes from five inches up to fifteen inches in depth, and, perhaps, make the greater proportion of beams used in this country. Trenton and Pittsburg works use different piles, the former endeavoring to compete with Buffalo and Phœnix by means of the old manner of piling, the latter using channel bar piles. Neither of these works, so far as we know, have been very successful in making beams over ten and twelve inches in depth. The supports for beams and girders have been always cast iron columns; but the wrought iron hollow columns, described in a former volume of the *Journal*, are gradually being appreciated. A building may be fire proof, and yet not indestructible. For example, a building may be filled with a combustible material, which, burning with an intense heat, will so unequally strain the the iron supports and flooring, that they must yield and carry with them to destruction everything under their influence. This is especially true where cast iron columns are used, which, when overheated, become as brittle as glass, and shiver, like glass, to atoms, should water be thrown upon them. Such columns will

stand no great tension, or any unequal straining, and ought to give place to wrought iron ones, especially in warehouses or other buildings used for general storage purposes. Office buildings not being subject to the conditions of a warehouse, can have cast iron columns to support the girders, and with good advantage. Attempts have been made to arrange a water circulation in the interior of columns to keep them cool in case of fire among store goods, but we have heard of no success attending the effort. There is one thing certain, and that is, any fire proof building, intended for storage purposes, should have the iron construction, as far as is possible, a wrought iron one. And it is desirable that even wrought iron should be protected from the direct action of flame by means of some non-conducting material. Intense heat will destroy the strength of wrought iron as well as that of cast, but it will stand an infinitely greater heat before it will yield. Plastered timber, so long as the plaster remains upon it, cannot be affected by ordinary fires, and is, practically, fire proof. Any means, therefore, by which a plaster composition could be attached to exposed parts of iron work, would be a great benefit in fire proof warehouse construction, and would make them in reality what they are only in name. If columns could be cased with a durable cement, leaving an air space between the column and casing, it would be an absolute impossibility for the iron column to become heated to destruction. In fact, it may be said, that no iron building is fire proof simply because it is of iron. The chances of fire are, of course, greatly lessened, but it can be destroyed by fire, and until a building can be made proof against *destruction* by fire, as well as *non-combustible*, we are far from perfection, in this class of buildings at all events.

In another number we propose to take up some of the more recent iron constructions of New York, illustrate some of their detail and connections, and make some comment upon the distribution of material. We believe that most all professional matter has been published to illustrate *good* practice. Finally, convinced that *bad* practice is as necessary to be recorded as good, we propose to contribute our mite on that side of the account. A chart, showing the deep water, is valuable and necessary to the navigator; but, by puttingupon it the rocks and shoals, we show him not only what to do, but what to avoid.

A. P. B.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

By G. S. Morison, C. E.

(Continued from page 164.)

For the arrangement in which the most economical division of panel is adopted,

$$c = b\,\frac{n}{m+n}$$

and the whole web is proportional to

$$\frac{(m+n)\,a^2 + \frac{m\,n}{m+n}\,b^2}{b}$$

which is a minimum when

$$\frac{m\,n}{m+n} - (m+n)\frac{c^2}{b^2} = o$$

$$b = a\,\frac{m+n}{\sqrt{m\,n}}$$

Table II.

Value of m ($n=1$)	Relative Material in Web.				Economical inclination of strut.
	1st arrangement. Ties vertical.	2d arrangement. Struts vertical.	3d arrangement. Ties and struts equally inclined.	4th arrangement. Most economical.	
4	$5\,a^2 + 4\,b^2$	$5\,a^2 + b^2$	$5\,a^2 + 1\frac{1}{4}\,b^2$	$5\,a^2 + \frac{4}{5}\,b^2$	$\frac{1}{5}\,b$
3	$4\,a^2 + 3\,b^2$	$4\,a^2 + b^2$	$4\,a^2 + b^2$	$4\,a^2 + \frac{3}{4}\,b^2$	$\frac{1}{4}\,b$
2	$3\,a^2 + 2\,b^2$	$3\,a^2 + b^2$	$3\,a^2 + \frac{3}{4}\,b^2$	$3\,a^2 + \frac{2}{3}\,b^2$	$\frac{1}{3}\,b$
1	$2\,a^2 + b^2$	$2\,a^2 + b^2$	$2\,a^2 + \frac{1}{2}\,b^2$	$2\,a^2 + \frac{1}{2}\,b^2$	$\frac{1}{2}\,b$
$\frac{1}{2}$	$1\frac{1}{2}\,a^2 + \frac{3}{4}\,b^2$	$1\frac{1}{2}\,a^2 + b^2$	$1\frac{1}{2}\,a^2 + \frac{3}{8}\,b^2$	$1\frac{1}{2}\,a^2 + \frac{1}{3}\,b^2$	$\frac{2}{3}\,b$
$\frac{1}{3}$	$1\frac{1}{3}\,a^2 + \frac{1}{3}\,b^2$	$1\frac{1}{3}\,a^2 + b^2$	$1\frac{1}{3}\,a^2 + \frac{1}{3}\,b^2$	$1\frac{1}{3}\,a^2 + \frac{1}{4}\,b^2$	$\frac{3}{4}\,b$
$\frac{1}{4}$	$1\frac{1}{4}\,a^2 + \frac{1}{4}\,b^2$	$1\frac{1}{4}\,a^2 + b^2$	$1\frac{1}{4}\,a^2 + \frac{5}{16}\,b^2$	$1\frac{1}{4}\,a^2 + \frac{1}{5}\,b^2$	$\frac{4}{5}\,b$

the web then being proportional to

$$2\,a\,\sqrt{mn}$$

When $m = n$, and the material of the web is equally capable of sustaining tension or compression, the third and fourth arrangements given above coincide, and the Warren Girder with braces inclined at an angle of 45° (the length of panel being twice the length of the truss), becomes the most economical form of web. For other cases, the relative economy of the four arrangements will appear from the tables. In Table II. a denotes the depth of truss, and b the length of panel as heretofore; in Table III. the most economical length of panel is adopted in each case, and the value of the web reduced in each case to decimals of the cost of a web of the most economical form.

TABLE III.

$\frac{m}{n}$	1st arrangement. Vertical ties.		2d arrangement. Vertical struts.		3d arrangement. Ties and struts equally inclined.		4th arrangement. Most economical.		
	Economical length of panel.	Material in web.	Economical length of panel.	Material in web.	Economical length of panel.	Material in web.	Inclination of strut.	Economical length of panel.	Material in web.
4	1·118 a	2·236	2·236 a	1·118	2 a	1·25	$\frac{1}{2}$ b	2·5 a	1
3	1·155 a	2·	2 a	1·155	2 a	1·155	$\frac{1}{3}$ b	2·309 a	1
2	1·225 a	1·732	1·732 a	1·225	2 a	1·061	$\frac{1}{3}$ b	2·121 a	1
1	1·414 a	1·414	1·414 a	1·414	2 a	1·	$\frac{1}{2}$ b	2 a	1
$\frac{1}{2}$	1·732 a	1 225	1 225 a	1·732	2 a	1·061	$\frac{2}{3}$ b	2·121 a	1
$\frac{1}{3}$	2 a	1·155	1·155 a	2·	2 a	1·155	$\frac{3}{4}$ b	2·309 a	1
$\frac{1}{4}$	2·236 a	1·118	1·118 a	2·236	2 a	1·25	$\frac{4}{5}$ b	2·5 a	1

From these two tables, the following practical observations may be derived:

Between the limits $\frac{m}{n} = 3$ and $\frac{m}{n} = \frac{1}{3}$, the third arrangement (Warren Girder), is the most economical of the three forms of web in common use, while between the limits $\frac{m}{n} = 2$ and $\frac{m}{n} = \frac{1}{2}$ its cost

differs so little from the theoretical minimum that, allowance being made for the simplicity of its connections, it may practically be regarded as the most economical arrangement. It possesses the further advantage of giving a point of support in the centre of each panel, as the floor may be suspended by a light rod from the intersection of the strut and tie with the top chord. For structures entirely of wood or of iron, $\frac{m}{n}$ will always fall within the limits last given, and if in that case the connections of the middle panels be so made that the same bars are capable of acting both as struts and ties, no additional counter-bracing will be needed, and a very economical web will be the result.

The first arrangement (vertical ties), is the most economical of the three common forms, when $\frac{m}{n}$ is less than $\frac{1}{3}$. In composite structures in which wood is used for the struts and iron for ties, $\frac{m}{n}$ will often be less than $\frac{1}{2}$, and in certain localities where wood is cheap, and iron dear, may be less than $\frac{1}{3}$; hence the merit of this form of web for such structures, and it has the further advantage of being effectively counter-braced by the addition of counter struts alone, no additional ties being needed. The Howe truss, in which this arrangement is adopted, has become the standard form of wooden bridge, though as commonly constructed, with short panels, counter-braces carried from end to end, and useless vertical posts over the supports, this bridge is far from being the economical structure it is capable of being made.

The second arrangement (vertical struts), is the counterpart of the first, and is an economical form when $\frac{m}{n}$ exceeds 3. It is superior to the first arrangement in structures entirely of iron, because a greater section of strut than of tie is then needed, but it is inferior to the third arrangement in this case. In composite structures it is very much the most costly form of the three.

The economical length of panel is always greater than the depth of truss, and in many cases, double the depth. So great a length of panel is inconvenient from the distance it leaves between the available points of support; but the panels may be shortened materially, without greatly increasing the cost. Table IV. shows the relative cost of the web of the third arrangement for different lengths of panels. Table V. gives the same for the first arrangement when

$\frac{m}{n}=\frac{1}{2}$ or $\frac{1}{3}$, and for the second arrangement when $\frac{m}{n}=2$ or 3, these cases being counterparts. It will be seen that after the length of panel is reduced to about half the economical length, the increase in cost becomes very rapid.

The material in the web depends upon the ratio between the length of panel and the depth of truss, and hence, if the inclination of the bars is left unaltered, the cost of the web is independent of the depth of the truss. This may appear anomalous, but it is to be remembered that though the length of the braces is increased, their number is diminished. In practice, however, the cost of the web will increase slightly with the depth, unless the struts are of such a form that the strength per unit of section is independent of the length.

TABLE IV.

Length of panel.	Angle of braces.	Relative material in web.
·5 *a*	75° 58′	2·125
·75 *a*	69° 27′	1·521
a	63° 26′	1·25
1·1 *a*	61° 11′	1·184
1·2 *a*	59° 2′	1·133
1·3 *a*	56° 59′	1·094
1·4 *a*	55°	1·064
1·5 *a*	53° 8′	1·042
1·6 *a*	51° 20′	1·025
1·7 *a*	49° 38′	1·013
1·8 *a*	48° 1′	1·006
1·9 *a*	46° 28′	1·001
2 *a*	45°	1·

In proportioning the several members of the web, the sections should of course correspond to the ordinates of the curves in Fig. 11. The following rule will often be found useful; though not

strictly accurate, the error is on the safe side. Make the centre braces capable of bearing one-eighth of the whole moving load ($\frac{1}{8}\ w'\ l$), and the end braces capable of sustaining one-half the entire load, and average the intermediate braces between those at the end and centre. The counter-braces may be proportioned in a similar way, graduating from the centre to the panel in which no counter is needed.

TABLE V.

Length of panel.	Relative material in web when $\frac{m}{n} = \frac{1}{2}$ (1st Ar.) or 2 (2d Ar.)	Relative material in web when $\frac{m}{n} = \frac{1}{3}$ (1st Ar.) or 3 (2d Ar.)
·5 *a*	1·876	2 125
·75 *a*	1·371	1·521
a	1·155	1·25
1·2 *a*	1·068	1·144
1·4 *a*	1·023	1·064
1·6 *a*	1 003	1·025
1·732 *a*	1·	.....
1·8 *a*	1·001	1·005
2 *a*	1·010	1·

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Concluded from page 176.)

"In such extreme cases of high speed belts, find the breadth of the first motion belt, by the formula for ordinary belting above (*a*), then if—

A = acting area of first motion belt.
v = velocity of first motion belt.
a = acting area of high speed belt.
V = velocity of high speed belt.

$$a = \frac{A v}{V}.$$

The acting area of either belt $= l \times b$, where l = length of circumference of driven pulley embraced by the belt,

b = breadth of the belt.

$$\therefore b = \frac{a}{l} \text{ in the case of the high speed belt.}$$

"If there is no first motion belt exclusively for the machine, it will be easy to suppose a hypothetical case from which the breadth of the high speed belt may be calculated."

15. From Haswell's *Engineer's Pocket-Book*, 1867 edition, we take the following: "A 4-horse engine transmits its power through a leather belt over a cast iron pulley 4 feet diameter, running one hundred revolutions per minute and embracing ·4 of its circumference.

"In this example the thickness of belt is taken at ·15 inch, and the strain at 210 pounds, which gives 4·67 inches for width of belt, and 122·26 square feet of belt per minute per horse-power, or 101·88 square feet, when ·5 of the circumference of pulley is embraced, using Morin's ratio of 2 : 2·4. If thickness of belt be taken at $\frac{3}{16}$ inch, and half the circumference be embraced by belt, then we have 81·375 square feet per minute per horse-power.

"An 11-inch belt on a 4-foot pulley running from 1200 to 2100 feet per minute will transmit the power of a double steam engine with 6-inch × 11-inch cylinders, 125 revolutions per minute, under a steam pressure of 60 pounds per square inch."

16. Fairbairn, in his treatise on "Mill Work," gives a table "for

determining the least width of straps for transmitting various amounts of work over different pulleys. The velocity of the belt is assumed to be between 25 and 30 feet per second, and the widths of the belts are given in inches. With greater velocities the breadth may be proportionably decreased."

The following formula will meet every requirement of the table:

$$W = \frac{5940 \text{ H P}}{1650\ d}.$$

In which W = width of belt in inches.
H P = horse-power.
d = diameter of smaller pulley in feet.
1650 = average speed in feet per minute,

from statement above, and which might be changed for v = velocity of belt in feet per minute to make the rule more general, which would seem to be allowed by the closing paragraph of the quotation.

The use of d in this formula forbids the naming of any definite area of belt running per horse-power per minute. If we take, however, the cases of belts from 12 inches to 24 inches wide on a 6-foot pulley, transmitting from 20 to 40 horse-power, and giving 82½ square feet of belt per minute per horse-power, we would not be stepping outside the line of usual good practice in selecting average examples from the table. But if we select from one extreme of the table a 1·4 inch belt running on a 10-foot pulley, transmitting 4 horse-power, or 48·125 square feet of belt per minute per horse-power, we will find it, if not out of the limits of possibility, certainly not within the ordinary economy of practice as to width of belt and diameter of the pulley. On the other extreme, the proportion of a 43·2-inch belt, running on a 12-inch pulley, and transmitting 12 horse-power, or measuring off 495 square feet of belt per minute per horse-power, is such an excessive one that perhaps it never has and certainly never should be used in practice.

Is it a subject of wonder, then, that we find in this work that belts are charged with "cumbrousness, the expense of their renewal and the necessity for frequent repairs," when from disproportion of pulleys and belts, such immense allowance of width must be made to gain the required adhesion?

17. From J. W. Nystrom's *Pocket-Book of Mechanics*, we take the following, in which—

b = breadth of leather belt in inches.
H = horse-power transmitted by belt.

v = velocity of belt in feet per sec.
d = diameter in inches. } of smaller pulley.
n = revolutions per minute. }
F = force in pounds transmitted by belt.
a = number of degrees of belt contact with smaller pulley.

$$v = \frac{d\,n}{230} \qquad b = \frac{7500\ \text{H}}{d\,a}.$$

$$\text{H} = \frac{v\,\text{F}}{550} \qquad b = \frac{13{\cdot}5\ v\,\text{F}}{d\,a}.$$

$$\text{H} = \frac{d\,n\,\text{F}}{126{,}500} \qquad b = \frac{n\,\text{F}}{18{\cdot}8}.$$

$$\text{F} = \frac{126{,}500\ \text{H}}{d\,n} \qquad b = \frac{29\ n\,\text{H}}{v\,a}.$$

18. "Having made practical use of the following table for several years with perfect satisfaction, I cheerfully recommend it to all who may at times be in want of reliable information with regard to belts."

We give an example from table which will fairly represent all therein.

A 6-inch belt, running 2200 feet per minute gives 12¼ horse-power, which = 89·8 square feet per minute per horse-power.—W. B. in *Sci. Amer.*, March 3, 1860, page 150.

19. "The belt that drives our establishment was originally 10 inches wide, but is now stretched to about 9 inches. It transmitted the full power of a 10-inch × 20-inch engine when working under 70 pounds of steam to the square inch. The driving side of the belt ran under a 36-inch iron pulley on the engine shaft, turning a 36-inch one on the line shaft, the slack side sagging 10 inches to 12 inches when at full work and it never slips."

"This belt has not been touched during the past three years, except to relace it, and has been running almost every day since it was started."—T. McG., Jr., in *Sci. Amer.*, March 24, 1860, p. 197.

20. "To find the power of a belt: The width in inches, multiplied by the velocity in feet per minute, divided by 1070, equals the power."

"Ex. $5 \times 2000 \div 1070 = 9{\cdot}345$ horse-power."

This rule gives 89·17 square feet per horse-power per minute.—D. E. C. in *Sci. Amer.*, March 24, 1860, p. 197.

21. "The following, by an eminent machinist, has been found to

answer perfectly for belting, and has been used by one having many years experience in constructing engines and mill work."

"It is calculated to give some 25 per cent. surplus power before material slippage of belt can occur."

$$W = \frac{H\,P\ 5400}{V\ d}.$$

In which W = width of belt in inches.
H P = horse-power.
V = velocity of belt in feet per minute.
d = diameter of smaller pulley in feet.—
R. F. in *Sci. Amer.*, Sept., 1855, page 14.

22. An horizontal non-condensing engine, with a cylinder 12 inches diameter, 30 inches stroke, running 66 revolutions per minute, under 72 pounds of steam in boiler and an average pressure of 19·7 pounds of steam on piston, has a 13½-inch belt on an 8-foot fly-wheel pulley, which runs over a 4-foot pulley on a shaft 18 feet vertically above. Speed of belt 1658·58 feet per minute. On one occasion the indicator showed 21 horse-power transmitted, this would give 88·81 square feet of belt per horse-power per minute.

23. An engine similar to that above, with 10 inches × 24 inches, cylinder, making 80 revolutions per minute, under 100 pounds of steam in the boiler, and showing by the indicator a constant work of 33 horse-power, has a 11½-inch belt on a 5-foot pulley on engine shaft. This belt is crossed and runs over a 34-inch pulley on the "line" shaft 8 feet above and 18 feet distant. Number of square feet of belt transmitted per horse-power per minute 36·5. Speed of belt 1256 feet per minute.

24. An engine like example No. 22 has a cylinder 15 inches diameter, 36 inches stroke; fly-wheel pulley 12 feet diameter, carrying a 17½-inch belt, which passes over a 5-foot pulley, 6 feet above and 18 feet 6 inches distant; top fold of belt slack.

Engine makes 48 revolutions per minute under 65 pounds of steam, and by the indicator shows a work done of 40·7 horse-power. Speed of belt 1809·12 per minute, and square feet of belt transmitted 64·61 per horse-power per minute.

25. An horizontal non-condensing engine, with 11 inches × 30 inches cylinder, arranged with two steam and two exhaust valves of the double beat balanced Cornish style, each operated by a cam, the two former under the control of the governor. A 10-foot fly-wheel pulley carries a 20-inch belt. On the line shaft 6 feet above and

15 feet distant is a 5-foot pulley, the belt passes over this pulley, the top fold running slack. Under 80 pounds of steam in the boiler a pressure of 60½ pounds per square inch on the piston is maintained to the point of cut-off, which was one-third the stroke on one occasion when the indicator showed a work of 29·27 horse-power; speed of engine 56 revolutions per minute. The load of this engine is very variable; the average of a number of cards taken show 25 horse-power. Speed of belt 2098·26 feet per minute, and number of square feet of belt per horse-power per minute transmitted 83·92.

26. A 20-inch × 48-inch cylinder horizontal non-condensing engine has a 16-foot fly-wheel pulley carrying a 24-inch belt, and runs about 50 revolutions per minute. This belt drives a 5 feet 4 inches pulley, 32 feet distant in an angle of about 40°, the top-fold slack. By the indicator the engine is working up to 150 horse-power. Speed of belt 2513 feet per minute, and square feet transmitteed per minute per horse-power equals 33·5.

27. An 18-inch × 36-inch engine, having a 14-foot 8-inch fly-wheel pulley, making 52 revolutions per minute, carries two belts; a 15-inch running over a 5-foot pulley directly above, 45 feet distant, and a 16-inch, running over a 6-foot pulley 20 feet distant, at an angle of about 30°.

This engine, under a boiler pressure of 85 pounds, shows by the indicator, 114·6 horse-power. Speed of belts 2392 feet per minute, and square feet of belt transmitted per minute per horse-power 54.

28. A 14-inch by 36-inch cylinder engine similar to No. 22 has a 12-foot fly-wheel pulley carrying an 18-inch belt, tight fold below at an angle of about 30°. Pulley on line shaft 6 feet diameter, and about 25 feet distant. Speed of engine 56 revolutions per minute. Horse-power by the indicator 49. Speed of belt 2111·2 feet per minute, and square feet per horse-power per minute 64·63.

Examples 12 and 22 to 28 inclusive, represent belting in constant use in this city—engines and machinery constructed by different parties.

The usual rating of engine in example 22 is 30 horse-power, which would give 62·17 square feet of belt per horse-power per minute.

Engine in example 23 is usually called a 20 horse, and at this estimate we should have 60·183 square feet of belt per horse-power

per minute. As now running the engine and belt are over-worked which is amply shown by the destructive wear of both.

Example 24 is doing very well, and may be considered a very good proportion, except shortness of belt, 8 or 10 feet more of which would increase adhesion and lessen friction.

Example 25 is a fair one, belt in use eight years, is in good condition, never slips and runs freely. The belt might be a little longer.

No.	Square feet of belt per horse-power per minute.		No.	Square feet of belt per horse-power per minute.	
	A.	B.		A.	B.
1	100·	.....	18	89·80	89·80
2	66·666	66·666	20	89·17	89·17
3	100·	.....	22	88·81	62·17
4	64·8	64·8	23	36·50	60·183
5	91·63	91·63	24	64·61	64·61
6	23·8	.....	25	83·92	83·92
8	39·27	.....	26	33·50	62·70
9	66·666	66·666	27	54.	77·24
"	69·44	69·44	28	64·63	79·15
10	75·	75·	A	75·	75·
11	125·	.....	B	62·79	62·79
13	97·232	97·232	C	68·69	68·69
14	91·666	91·666	D	47·61	.....
15	81·375	81·375	E	89·89	89·89

Column A gives an average of 72·873
" B " " 75·899

Example 26 is that of an over-worked engine and belt. That size cylinder should not do over 100 horse-power, where long continued service in good running order is desired, and owing to a faulty plan in arrangement of parts of engine, 80 horse-power

would be a sufficient load, at which latter rate we should have 62·7 square feet of belt per horse-power per minute.

Example 27 is that of another engine doing severe labor; at 80 horse-power, giving a belt area of 77·24 square feet per minute, this engine would run in every way much better, of which we have ample proof in the shape of several break-downs.

Example 28 has been running about 3½ years, gives great satisfaction, is called a 40 horse engine which would give a belt area of 79·15 square feet per horse-power per minute.

In column A of the above table is given consecutively the square feet of belt per horse-power per minute of the foregoing rules. Examples A, B, C, D and E are taken from the *Franklin Institute Journal* of January, 1868, page 24.

In column B are rejected all the results of 100 square feet and over and all under 50, which are either from assumed or *overworked* examples.

The extremes of practice seem to run from 33·5 to 100 which are worth noting, while 75 square feet per minute per horse-power seems a fair average of the best attested examples.

It is to be hoped that all who are in the line of practice with belts will contribute to our limited stock of published results of this all but universal method of transmitting power.

Philadelphia, August, 1868.

ACTION OF UNDER-CURRENTS IN THE MISSISSIPPI.

By James B. Eads, C. E.*

Examinations made by myself and other engineers, have revealed the fact that the bed-rock of the river, which is limestone, is overlaid with a deposit of sand about fifteen feet deep near this shore, and perhaps 100 feet at the other; the increase in depth being very regular as we proceed towards the Illinois shore. The borings, as far as made, indicate a regular slope of the rock from this shore, which has been traced as far as the location of the eastern channel pier, where it is about seventy-nine feet below the deposit. Near the Illinois shore, ninety feet of boring has failed to reach the rock. The sandy bed of the river in low water is nearly level.

* From Report on Illinois and St Louis Bridge.

Soundings made by me prove that this deposit is scoured out to a great depth in time of floods and freshets. Although I have not had any extreme stage of water in which to make my observations, I found that a rise thirteen feet less than high-water mark caused a scour of eighteen feet. The greatest variation in the height of the river known at this place is about forty-one feet. An average depth of about eight feet, with a width of 1,600 feet, represents the volume of the river at extreme low water at the location selected. Extreme high water covers an immense area of bottom lands above and opposite the city, and the construction of numerous railway dykes across these from East St. Louis, reduces the water-way at Washington avenue to about 2,200 feet in width at high-water mark. On this shore and on the other, this water-way is thoroughly revetted below the low-water line with rubble stone and protected by the wharf pavements above that line. The concentration into this narrow channel of the vast volumes that are sometimes poured out of the gigantic-net-work of streams above St. Louis, the main artery alone of which is navigable over a thousand leagues above this city, assures me that in time of floods it is not improbable that this deposit is removed to twice or thrice the depth shown by my soundings, and perhaps to the rock itself.

I had occasion to examine the bottom of the Mississippi, below Cairo, during the flood of 1851, and at sixty-five feet below the surface I found the bed of the river, for at least three feet in depth, a moving mass, and so unstable that, in endeavoring to find footing on it beneath the bell, my feet penetrated through it until I could feel, although standing erect, the sand rushing past my hands, driven by a current apparently as rapid as that at the surface. I could discover the sand in motion at least two feet below the surface of the bottom, and moving with a velocity diminishing in proportion to the depth at which I thrust my hands into it.

It is a fact well known to those who were engaged in navigating the Mississippi twelve years ago, that the cargo and engine of the steamboat America, sunk 100 miles below the mouth of the Ohio, was recovered, after being submerged twenty years, during which time an island was formed over it and a farm established upon it. Cotton-wood trees that grew upon the island attained such size that they were cut into cord-wood and supplied as fuel to the passing steamers. Two floods sufficed to move every vestige of the island, leaving the wreck of the America uncovered by sand, and forty feet

below low-water mark, where, in 1856, the property was recovered. Pilots are still navigating the river who saw this wreck lying near the Arkansas shore, with her main deck scarcely below low-water mark at the time she was lost. When the wreck was recovered the main channel of the Mississippi was over it, and the hull of the vessel had been cut down by the action of the current at the bottom, nearly forty feet below the level at which it first rested; and the shore had receded from it by the abrasion of the stream nearly half a mile.

These remarkable, but well attested facts, came under my own observation, and occurred at Plumb Point, one hundred miles below Cairo, where the Mississippi is more than one mile wide, and where the lateral action of the current is not confined as it is here by stone, and where the depth of the action of the under currents must be much less than at this narrow passage.

Singularly enough, the fact is almost certain that at seasons of *lowest* water, this deposit is also liable to be removed to an extent probably sufficient to lay bare the rock in mid-channel. The current being much less when the water is low, the sand accumulates to its greatest depth. When the river freezes over, which only occurs when it is quite low, a strong crust of ice, from ten to fifteen inches thick, is formed in this narrow gorge, while there are frequently great stretches of the river above unclosed. The floating ice formed in these open spaces is carried down in large masses, which accumulate in this and other narrow passages of the river, and form what are termed ice gorges. These accumulations sometimes extend several miles above the contracted channels of the river, and cause the water to rise, or in river parlance, "back up," ten and even twenty feet in some instances, above its former level. The firmly frozen crust serves to hold the masses that are accumulated beneath it, and the great height attained by the "backing up" of the water above the gorge increases the currents that are sweeping below the ice to a degree probably greatly exceeding that of the floods, if we may take the water levels above the gorge as an index to the current created by this hydrostatic pressure. These currents, I believe, would prove too great to be resisted by any ordinary rip-rap (or loose stone) usually used to protect foundations not resting on the rock. The ice being lighter than the water, it follows that these currents will be constantly acting beneath the gorged ice, and in direct contact with the sand. As rapidly as the latter is cut away,

fresh supplies of ice are driven under, and thus the mass continues to grow in depth, and the current to be directed nearer to the rock. After a few weeks the pressure of the back-water becomes so enormous as to sweep the gorge away, and on such occasions the open space of water below the gorge is at once filled for miles with the submerged ice thus liberated. This ice can readily be distinguished from the crust or surface ice by its scarcely floating, and by the quantities of sand and mud with which it has been saturated during its imprisonment.

On two occasions, I undertook to cut a channel in the ice through which to remove from gorges two valuable diving-bell boats to places of safety. The undertaking was only successful in one case. The surface ice being removed from the canal and hauled off on its sides, I found the quantity of submerged ice which continually arose, when that in sight was removed, was so great that the supply seemed inexhaustible. In the case where I was successful, I was able to cut the channel from an open part of the river up to the vessel, and through it the submerged ice was floated out and the channel thus cleared.

In the winter of 1855, the steamer Garden City, of about 800 tons burden, was inclosed in the ice gorge which formed in this harbor. Many of our citizens will remember that a partial movement of the gorge caused her sides to be crushed, in consequence of which the vessel filled with water. She was lying at the upper part of the city in front of a large stone quarry, the debris from which had been for several years thrown into the river by the quarry-men, and had formed a steep, rugged shore of such slope as the broken stone naturally assumed. The water where the vessel sunk was twenty-five feet deep, but she was sustained upon the gorged ice beneath her, so that her deck was scarcely under the surface. She was in this condition when I was called upon to save her. Her hull being about nine feet in depth, it is evident that the ice which sustained her must have been packed to the bottom, and sixteen feet deep. This ice supported her with her engines and boilers, and a cabin over them about 150 feet long, until the bank was removed, ways placed on the ice under the steamer, powerful purchases secured ashore, and the vessel hauled broadside in to, and upon the bank in safety, before the gorge gave way. The time occupied in doing this was about ten days, nearly all which time the steamer

was resting on ice that had been driven under the surface by the action of the current.

The establishment of piers in the channel of the river must facilitate the formation of an ice gorge at the bridge in the winter, and they will certainly tend to its retention until the sand is scoured out about and between them to an unknown depth.

For these reasons I have maintained and urged that there is no safety short of resting the piers for your bridge firmly upon the rock itself. On no other question involved in its construction does my judgment more fully assure me that I am correct, although the Convention of Engineers assembled here last summer announced in their report that they did not consider it essential to go to the rock with all the channel piers of Mr. Boomer's bridge. The Convention assumed that the greatest possible scour would not exceed thirty feet below low-water mark (equivalent to the removal of twenty-two feet of deposit. See Report, page 80.) I am supported in my opinion upon this matter by many eminent engineers with whom I have exchanged views upon the subject.

The recent destruction of many of the bridges in British India, by having their foundations undermined by the action of floods upon the sandy bottoms of the streams in that country, furnishes a warning that we should not neglect.

PROPOSED METHOD OF SINKING THE PIERS FOR THE ST. LOUIS BRIDGE.

By James B. Eads, C. E.*

A number of designs and estimates were made by me to determine the most practicable, economical and reliable method of constructing the parts of the channel piers below low-water mark. These designs and estimates included the use of cast iron cylinders, of diameters varying in the different plans from three to fifteen feet, which were to be sunk to the rock and filled with concrete. The danger of scour, and the difficulty of binding these cylinders together beneath the surface of the sand, so as to insure stability under the strains produced by the thrust of the arches, induced me to increase their diameters in subsequent designs, until they became so great that wrought iron was substituted, and finally two cylin-

* From Report on Illinois and St. Louis Bridge.

ders, each of a diameter equal to the width of the pier, were tried with smaller ones about them, to complete the entire dimensions of the foundation. The same difficulty of binding these together in a manner to insure safety to the superincumbent masonry, in the event of deep scour, as well as to give promise of any great durability, still remained.

Cast iron cylinders may be used with great advantage in forming subaqueous foundations in situations where there is no scour, but the dangers to be guarded against in this location would render them, I think, less reliable and more expensive than other methods.

My experience of the effects of fresh water upon wrought and cast iron, submerged for many years in the Mississippi, assures me that the latter can be relied upon as almost indestructible, but that wrought iron will oxidize or rust out so rapidly that in twenty years the strength of a bolt an inch and a half in diameter would probably be reduced one-half. To bind these cylinders together, beneath the sand, would greatly increase the cost of adopting them, and to use wrought iron to secure them above the sand would fail to insure durability. To undertake to do it with cast iron would be more expensive, and the slightest unequal settlement of the different ones composing the mass would be likely to fracture a material so brittle. To sink these cylinders, either by the pneumatic process, or by any of the methods known, to the requisite depth, would be exceedingly expensive. The great quantity of iron required in them, and the fact that they must be filled with masonry, would render a foundation of the necessary dimensions, if composed of them, much more expensive than if made of stone alone.

Having arrived at this point in the solution of the most important problem connected with the design and erection of your bridge, I determined to construct the base of the pier entirely of solid masonry, within a water-tight floating coffer-dam, whose sides should be extended above water from time to time, as it sunk deeper and deeper, with its increasing burden of stone and cement.

Piers of smaller dimensions have been constructed in a similar manner, and placed upon foundations favorable to their permanent reception. When sand or mud has been interposed, and its removal rendered necessary, the sides of the floating vessel have been extended downward below its bottom, to form a chamber or kind of diving-bell beneath the masonry. Through the masonry tubes were provided, by which workmen and materials could descend into the

chamber, and through these tubes air was forced to expel the water from the chamber, and enable the workmen to remove the sand or mud beneath the pier. These tubes required to have two or more air-locks or valves in them, that were closed behind the workmen or materials in their passage, to prevent the escapement of the compressed air in the chamber. This, of course, retarded the rapid progress of the work. To facilitate the excavation of the deposit an extra tube was introduced in the middle of the pier, and extended to the level of the bottom of the air chamber. The water stood within this tube at the level of the surface of the river, and through it an endless chain, carrying scoops or excavators, was made to rotate around a pulley at the bottom of the tube, and another at the top. In this way the sand was rapidly excavated without permitting the escapement of air from the chamber, and without passing the deposit up through the air-locks. The workmen in the chamber were enabled to shovel it to the bottom of the tube, where it was taken by the excavator, and discharged in vessels above.

The gradual descent of the pier was managed by screws, supported upon false works, erected around and over the site of the pier. As the sand was removed below, the pier was allowed to settle by slacking the screws, as it was only partially water-borne. When it had passed through a considerable depth of sand, the friction of the latter upon the sides of the pier held it to such a degree as to take all the strain off the screws, and when it moved downward, it was sometimes so suddenly that the supports were strained severely.

The shortness of the season in which each one of the piers for this bridge must be put in position, because of the floods of summer and the ice of winter, and the great amount of deposit to be removed, renders the pneumatic process just described too slow for this case, as well as too expensive. For the safety of the workmen beneath the pier, it is absolutely necessary to regulate its descent by screws or similar means, and to do this with piers of such magnitude would not be advisable.

The removal of the sand will be accomplished by sinking an elliptical-shaped caisson or curb of plate-iron through the deposit to the rock. This caisson will be open at top and bottom, and will be strongly braced on the inside with heavy angle irons placed horizontally around it. It will be larger at bottom than top, to facilitate its passage through the sand and relieve it of the friction. The

caisson will be suspended by false works erected around the site of the pier, and will be regulated in its descent by screws supported on the false works. As it is lowered into the sand, that which is inclosed by it will be excavated by steam machinery, until the caisson is finally sunk to the rock. It is not intended at any time to remove the water within the caisson, but only the sand it encloses; the object of the caisson being only to exclude the sand outside of it until that which it encloses has been removed, the rock leveled off with concrete, the floating coffer-dam placed in position within the caisson, and the pier so far built up in the latter as to sink it down to the concrete bed prepared for it.

The bottom of the coffer-dam will be formed of squared timbers, thoroughly caulked, and will be about two feet in thickness. Its sides will also be of timber, and so constructed as to admit of being disengaged from the bottom when the latter has reached the bed formed to receive it. The interior of the coffer-dam will be larger than the pier, and the latter will be constructed with certain cavities in it to be filled with masonry after the pier reaches the bottom, so that the weight of the pier will bear such proportion to the displacement of water as to insure the top of the masonry being kept but little below the surface of the river while the pier is being built within it. This will enable the sides of the vessel to be thoroughly braced against the pier, so as to resist the pressure of the water.

It is known that timber is indestructible when completely submerged in fresh water, Piles placed in the Rhine by the Romans, nearly 2,000 years ago, have been found to be entirely sound when removed within the present century. There are many other similar instances on record establishing the fact of its durability, whilst the soundness of the timber found in the bogs of Ireland and elsewhere indicates that it is unlimited by time.

When the bed rock has been prepared to receive the pier, the coffer-dam will be floated within the caisson, and will be guided by the latter as it descends with its load. It will be understood that the pier is completely water-borne by the coffer-dam until the quantity of masonry in it has become so great as to cause the dam to touch the bed on which its bottom, with the pier, is to rest permanently. When the pier has been completed above water, the dam is permitted to fill, and its sides will then be disengaged from the bottom and removed, to be used in putting down the next pier.

The caisson for the smaller pier can be withdrawn and used for the other one; and the larger one may possibly be saved also.

As before stated, the floating coffer-dam is not an untried experiment, but has been frequently used to place piers in position where the bed-rock or other substratum was favorable for their reception. The caisson has also been frequently used to exclude the sand or mud, and enable that within it to be removed sufficiently to facilitate the driving of piles to a greater depth and in firmer soil than would be otherwise practicable.

The estimates made for the cost of this work prove that it will be much less expensive than any other method yet devised; while the superiority of the foundations thus made will be beyond all question.

The Theory of Puddling.—In a paper read before the late meeting of the British Association by Mr. C. W. Siemens, on the subject indicated above, a new and important view was expressed as regards the nature of the process in question.

As is well known, it has been generally assumed that the cast iron on the hearth of the reverberatory furnace combined with oxygen from the heated air mingled with the burning gases which played upon it, and that the impurities, such as silicon and carbon, were thus removed from the iron, the first in the form of gas, the latter as solid silica, which, combined with the oxide of iron or fettling, introduced and formed a slag.

According to Mr. Siemens' experiments, however, it is from the fettling, and not from the air, that the oxygen is derived, by which the impurities suffer conversion, and the only effect of the air in the flame is to burn or oxydize the iron. This was proved by employing a perfectly neutral flame (one with no excess of oxygen), when it was found that not only did the process advance as well as before, but that the weight of wrought iron produced was fully equal to that of the pig employed. Now as some part of the pig—*i. e.*, the impurities, was undoubtedly removed, we see that some of the fettling must have been reduced, which clearly supports the new and is opposed to the old theory.

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 186).

The Molecular Constitution of Matter.—The Atomic Theory of Boscovich.

Of the foregoing facts which we have brought together, concerning the general properties of matter and the effects of attraction and repulsion existing between the minute parts of bodies, we can frame a hypothetical theory which, in a few lines, or postulates, will embrace what we otherwise could not express in many pages.

This theory together with the doctrine of the Conservation of Energy, are the two most important generalizations in Physics, and, in our opinion, the following generalization forms an absolutely essential introduction to the proper study of this department of science.

The ancient Greek philosopher, Democritus, propounded an hypothesis of the constitution of matter, and gave the name of atoms to the ultimate unalterable parts of which he imagined all bodies to be constructed. In the 17th century, Gassendi revived this hypothesis, and attempted to develope it, while Newton used it with marked success in his reasonings on physical phenomena; but the first who formed a body of doctrine which would embrace all known facts in the constitution of matter, was Roger Joseph Boscovich, of Italy, who published at Vienna, in 1759, a most important and ingenious work, styled *Theoria Philosophiæ Naturalis ad unicam legem virium, in Natura existentium redacta.* This is one of the most profound contributions ever made to science; filled with curious and important information, and is well worthy of the attentive perusal of the modern student. In more recent days, the theory of Boscovich has received further confirmation and extension in the researches of Dalton, Joule, Thomson, Faraday, Tyndall and others.

We present here a generalization which, while giving the sub-

stance of the important postulates of Boscovich embraces others made necessary by the progress of science since 1760.

1. Matter has trilineal extension.

2. Is impenetrable.

3. Does not form a plenum.

4. All matter consists of indefinitely small but finite parts; of extreme hardness; indivisible, and unalterable by either mechanical or chemical means; and endued with impenetrability and inertia. These ultimate parts are called *Atoms.*

5. These atoms are not in mathematical contact, but are separated from each other by distances which are great when compared with the size of the atoms.

6. A union of atoms forms a molecule, and combinations of molecules form particles of which all bodies are composed.

7. There exist between the atoms, attractions and repulsions: when these tendencies are equal, the atoms preserve fixed positions and the volume of the body is constant. These molecular forces vary both in intensity and direction, by a change of distance, so that at one distance two atoms attract each other, and at another they repel; there being, within the distance in which *physical* contact is observed (about $\frac{1}{2000}$th inch), several alternations of attraction and repulsion.

8. The repulsion of two atoms generally diminishes more rapidly than their attraction when the distance between them is increased; while their repulsion increases more rapidly than their attraction when their distance is diminished.

9. The law of variation is the same in all atoms. It is therefore mutual; for the distance of *a* from *b* being the same as that of *b* from *a*, if *a* attract or repel *b*, *b* must attract or repel *a* with exactly the same force.

10. At all sensible distances (*i. e.* beyond $\frac{1}{2000}$th inch), this mutual tendency is attraction, and varies inversely as the squares of the distances. It is known as *gravitation.*

11. The last force which is exerted between two atoms as their distance diminishes, is an insuperable repulsion, so that no force however great can press two atoms into mathematical contact.

12. Between the molecules of *gases* continued repulsion seems to exist, so that when relieved of exterior force, a gas expands indefinitely.

Between the molecules of *liquids* exist attraction and repulsion,

Fig. 2

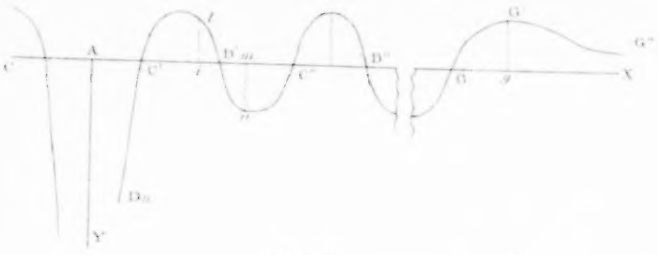


Fig. 3.

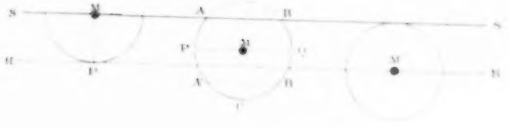


Fig. 4

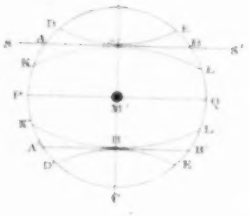


Fig. 5

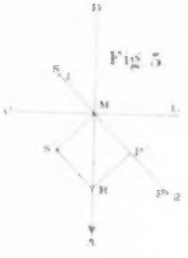


Fig. 6

Fig. 7

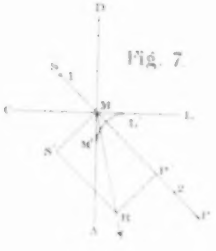


Fig. 8

which maintain them at determinate distances; but they have no fixed axial direction, so that a liquid molecule will rotate around any imaginary axis on the action of the slightest force. Thus liquids have *fluidity*, while at the same time they have a small range of compressibility.

In *solids* the molecules have, besides their mutual attractions and repulsions, *polarity* or fixity of position of their axes *inter se*, so that when a molecule in any solid is turned around any axis, it will return to its primitive position after a series of decreasing oscillations.

Those of the above postulates which refer to the mutual action of atoms, can be geometrically expressed by means of an exponential curve. See Plate IV., Fig. 2.

Let an atom be at A, while another is anywhere on the line AX. Suppose that when placed at *i* for example, that an attraction exists between the atoms. The intensity of this attraction is represented by the length of the line *i l*, and we show that mutual attraction exists by drawing the ordinate to the point *i above* the axis AX. If the atom be supposed at *m* and repelled by A, then the repulsion and its intensity are expressed by drawing the ordinate to the point *m*, below the axis AX. This may be supposed to be done for every point of the length AG, which represents the distance between the glass plates in Huyghens' experiment, or about the $_{2}0^{1}_{0}0$ inch, and thus we will form an exponential curve.

As there are several alternations of attractions and repulsions, the curve will consist of various inflections lying alternately above and below AX. The last inflection, most distant from A, viz: G′ G″ is of such a form that the lengths of its ordinates being the reciprocals of the squares of their distances from A, it expresses the law of gravitation; the atom at G being at the point called the *limit of gravitation*, or about $_{2}0^{1}_{0}0$ inch from A. AX will be an asymptote to this curve, while the inflection C′ D*n* will have AY for asymptote; for the ordinate expressing repulsion increases beyond all limit when the distance from A is just vanishing. The intermediate branches of the curve must be determined by means of the alternations of attraction and repulsion, in the experiments already described and by the aid of the various phenomena of capillarity and of molecular physics.

If an atom, supposed at the point C′, or C″, or &c., have its distance increased from A, it will, being under the curve, be attracted with an intensity represented by its ordinate. When set free it will

move with an increasing velocity towards its primitive position of equilibrium, which it will surpass on account of its inertia, and, coming into the sphere of repulsion, it will be repelled from A, and thus oscillate about its point of equilibrium. The atom will therefore eventually return to C′, or C″, or &c. These positions are called *limits of cohesion*, C′ being designated as the *last limit of cohesion*.

If an atom at D′, or D″, or &c., be moved ever so little from its position, it will rush to an adjacent limit of cohesion, either to the right or to the left, according as it was moved from or towards A. These points, D′, D″ &c., are called *limits of dissolution*, and differ from the limits of cohesion in being positions of unstable equilibrium, and therefore only a *temporary molecule* can be formed by an atom placed at D′, D″, &c., with an atom at A; while an atom at C′, C″, &c., together with the atom A forms a *permanent molecule*, which resists compression and dilatation, and whose component atoms return to their primitive positions when the extraneous force is removed; provided the compression or dilatation has not been too great; for, in that case, the atom C″, for example, might be forced beyond D′ by a compression, or removed beyond D″ by a dilatation, and would then rush to another position of permanent equilibrium, either to C′ or to G. The only molecule that cannot possibly be changed by compression is AC′. When, however, the amount of compression or dilatation of a body formed of permanent molecules is a very small fraction of its volume, the body regains the dimension it had before the compression or dilatation was applied, and it is found that the compression or dilatation is proportional to the force employed; for, in this case, the small portion of the curve which expresses the variation of repulsion or attraction may be considered a straight line, and therefore its ordinates are as its abscissas.

These logical consequences of the theory are confirmed by the most extensive experience. "Mr. Coulomb was engaged (for a particular purpose), in a series of experiments on the oscillations of springs, particularly of twisted wires. He suspended a nicely turned ball or cylinder by a wire of a certain length, and fitted it with an index, which pointed out the degrees of the torsion. He found that when a wire of twenty inches long was twisted ten times, the index returned to its primitive position, if repeated a thousand times, and the oscillations were made in equal times, whether wide or narrow.

But if it was twisted eleven times, the index did not return to its first place, but wanted nearly a whole turn of it. Here, then, the parts of the wire had taken new relative positions, in which they were again at rest. But what was most remarkable in Coulomb's experiments was this: He found that after the wire had taken this set (as it is termed by the artizans), it exhibited the same elasticity as before. It allowed a torsion of ten turns, and when let go, it returned, and after its oscillations were finished, it rested in the position from which it had been taken. I was much struck with this experiment, and immediately repeated it on a great variety of substances with the same result. The most inelastic substance that I know is soft clay. I got a thread made of fine clay at a pottery, by forcing it through a syringe. It was about $\frac{1}{12}$th of an inch in diameter, and eleven feet long. While quite soft (and smeared with olive oil, to prevent its stiffening by the evaporation of its moisture), I fastened it to the ceiling, and fixed a small weight and an index to its lower end. I found that it made $5\frac{1}{2}$ turns a hundred times and more, without the smallest diminution of its elasticity, always recovering its first position. But when I gave it 7 turns it returned only $5\frac{1}{2}$. Thus it took a set. In this new arrangement of its parts, I found that it again bore a twist of $5\frac{1}{2}$ turns without taking any new set. And I repeated this several times. I then gave it 10 turns, in the same direction with the first seven. It returned $5\frac{1}{2}$ as before, and was again perfectly elastic within this limit."

* * * * * * * *

"Another appearance of tangible matter shows a most encouraging conformity to the theory. Where bodies are very moderately compressed or dilated, the forces employed are proportional to the change of distance between the particles. This appears most exactly true in the experiments of Dr. Hooke, on which he founded his theory of springs, expressed in the phrase *ut tensio sic vis*, and his noble improvement of pocket watches by applying a spiral spring to the axis of the balance, which, by its bending and unbending, produced a force proportional to the angle of the oscillations, and therefore made them isochronous, whether wide or narrow. It is also confirmed by the experiments of Coulomb on twisted wires, and by the form of the elastic curve, as determined by Bemouilli, on the supposition that the forces with which the particles attracted and repelled each other, are proportional to their removal from their

natural quiescent positions. But it is found that when the compression or dilatation is too much increased, the resistance does not increase so fast; that it comes to a maximum by still increasing the strain, then decreases, and the body takes a great set or breaks. All this is perfectly analogous to the forces expressed by the ordinates of our exponential curve. In the immediate vicinity of the limits of cohesion, the ordinates increase nearly in the ratio of the abscissæ, then they increase more slowly, come to a maximum, decrease again, till we come to a limit of dissolution."

(To be continued.)

CORNISH PUMPING ENGINES

By W. H. G. West, First Asst. Eng., U. S. Navy.

In the July number of the *Journal of the Franklin Institute*, I find a paper upon this subject, from W. H. Henderson, Esq., Hydraulic Engineer, apparently intended to show the causes of the superiority of this kind of engine, but, in reality, to a careful reader proving, according to the author, that the rotative engine is equally good, or perhaps better.

In disposing of "the classified points of merit," he says (page 31), "Up to the point of cut-off the velocity of the weight is uniformly accelerated." This, Mr. H. here says, is an advantage; but on page 32 we find "a uniform speed of piston is required in the latter" pumping water.

The motion of the piston is accelerated until it has reached such a distance beyond the point at which the steam is reduced to the mean pressure as may be due to the energy stored up in the moving parts.

If in the Cornish Engine "the momentum acquired together with the force given out by the expanding steam, carries the piston to the end of its stroke," does not the *vis viva* or potential energy stored up in the moving parts of the rotative engine, together with the work done by the expanding steam, carry the piston of that engine to the end of its stroke, and does not the *steam* perform the *whole* work in either case?

The Cornish Engine passes through the steam stroke very rapidly. If the pressure at the end of the stroke equaled the resistance (page 31), the *vis viva* of the moving parts would shoot the piston through the cylinder-head, unless prevented by the

catches. Mr. H. gives us this same thing as a fault in the numerous direct-acting steam pumps (page 34), and in these words: "The terminal pressure must invariably be equal to the full load, or the pump will come to a dead stand." Now, why will not *momentum* help this unfortunate engine as well as the Cornish Engine? It will. Mr. H. knows it, and is convinced, too, that the terminal pressure need be no more equal to the full load in one machine than another, except where we have light moving parts, which, Mr. H. says, are bad for Cornish Engines (page 33), but good in any other engine (page 32).

On page 31, we find that the plunger descends with a "uniformly augmented velocity," and the momentum acquired is again stored up at the end of the stroke. The piston, and, therefore, the plunger, can *not* descend in this manner, for it is brought up by cushioned steam, just as that of the rotative engine is, and the velocity of each piston varies from full speed to a stand-still at each end. Where is the difference, and what ill effect would it have upon the engine, if Mr. Henderson's statement *were* correct? The fly-wheel would give back all the momentum or *vis viva* imparted to it, but the steam would not, in any engine.

Will Mr. H. call to mind that we find, in general practice, much higher steam used in rotative engines than in the Cornish, and will he favor us with an estimate of the amount of power, in steam, lost by this variable speed in any engine? None, I think. Two or three places in Mr. H.'s paper have been referred to where accelerated motion is described as a virtue.

In good rotative pumping engines the pump-rod is, and should be, attached to the piston-rod. Here we need but a light fly-wheel, heavy enough to overcome friction: for, though the steam is doing no work at the end of the stroke, there is no work to be done but that of overcoming friction.

No serious evil effects can result from increasing the speed of the plunger near the middle and towards the end of the stroke, for when the water is put in motion the plunger may move faster. Were the steam shut off, the *vis viva* of the moving water would carry the engine some distance with it, and the speed may, therefore, increase without loss, keeping the pressure against the plunger uniform. There is no loss here from variation of speed, except by friction; frictional resistance varies as the square of the speed, at low speeds, but as a higher power at higher velocities; and as the

Cornish Engine comes in like a rocket when it takes steam, we may infer that it is the least economical of engines, as far as that *serious quality* is concerned.

"We now pass to the saving of steam from loss by clearance and steam passages, and the isolation of the working-end of the steam cylinder from the cooling influence of the condenser." Isolation, in this case, means a "high degree of expansion," or very high temperature to very low temperature during the in-door stroke; then this low temperature—very little above that of the condenser—both sides of the piston during the out-door stroke; then exposure of all the cylinder but about a foot of the out-door end to this same temperature; and last, the exposure on the lower side during the in-door stroke to "the cooling influence of the condenser." That is saving by isolation with a vengeance. It is very well known that the pistons of Cornish Engines, perfectly tight at one end, leak badly at the other, when the cylinder has no casing, or when the casing is cold. This may well be expected from the difference of expansion of metal, and more especially in large Cornish Engines, where the grade of expansion is very high, and the corresponding differences of temperature are very great.

Cushion, in the rotative engine, means that the exhaust-valve closes just before the piston reaches the end of its stroke, and, shutting in a small quantity of the back-pressure steam, forms a cushion, which takes up the work remaining stored up in the moving parts. This, minus loss by condensation, is given out again immediately after the crank passes the centre.

Cushion, in the Cornish Engine, means shutting up steam, perhaps two pounds higher than that in the condenser, and compressing it to the same final pressure for the same size, weight and speed of engine, with the same degree of expansion. The operation, as well as the result, is the same in each case, and the only difference I can see is, that the valve is in one instance called the equilibrium, and, in the other, the exhaust.

On page 33, we have the following: "It is evident that by means of this cushioning, the loss from clearance and steam-ports is practically nothing, if the steam so compressed be equal to the *initial* pressure." How the extraordinary feat of forcing the piston up against the initial pressure is done by a simple weight, sufficient only to overcome the friction at a speed of about one hundred and fifty feet per minute, Mr. H. does not explain. It is more difficult

to comprehend than getting into a tub and lifting ones self by the handles; and even were it possible, the piston must instantly shoot back again, and we should have much of the water pumped out for nothing.

In the large rotative engine, a half inch is the usual clearance, and this cannot be afterwards changed. In the Cornish Engine, it depends entirely upon the cushioning; it may be changed by turning a small nut, and is changed by every rise and fall of steam. The stroke and power are also changed by every change of pressure, and as these changes become more considerable, the losses are increased.

Numbers of rotative pumping engines have poppet valves, and these valves are fitted so close to the inside of the cylinder that the piston passes within a half-inch of each valve-seat. There never has been a Cornish Engine built with such short ports.

The faithful return of *vis viva* is a very pretty fancy, but it does not apply to the Cornish Engine where it will not apply to the rotative.

Steam is not perfectly elastic; it condenses in expanding; it is condensed by radiation, and it cannot, therefore, return the *vis viva* imparted to it by the moving parts. There must be a loss, and the heavier the engine is, the greater will be that loss.

The advantage which the beam engine appears to have over the Bull engine is, that it *starts* its load with more ease. The Bull engine is generally more rigid than the beam engine, and in it we have a dead pressure from the beginning of the stroke; but the beam engine will have passed through some space, and will have given a velocity and an energy to the moving parts before the whole strain or weight of water comes upon the machinery; we then have two forces to start the load instead of one. But this advantage is so small that Bull engines do just as good duty as others—perhaps better; and one engine can be made to spring as much as another, if, at some risk, we make them weak enough.

The momentum (improperly called) of the piston and connections is given out gradually in the rotative engine, as the piston approaches the "dead point," and just before it reaches that point, momentum *vis viva*, or whichever is the correct word in this place, dies too, for here motion of the piston, &c., ceases, and without that, where is the energy? So not the smallest imaginable quantity is given

out through the crank-pin to the wheel, or anything else, at the "dead point."

Steam jackets may be applied to any engines, even to locomotives, and would be, too, if practical men thought it would pay. Numbers of marine and stationary engines have them. The Cornish Engine does not possess the sole right to wear jackets, any more than the rotative engine, only, enjoys the right of wearing its warm felt coat. The coal would do much better duty were the hot gases from it turned into the jacket, instead of being employed in evaporating water, half of which is condensed again before the remainder reaches the jacket.

The real causes of success of the Cornish Pumping Engine are so simple, that only men of very practical minds discover and appreciate them, and this simple machine remains a mystery even to those who have made its manufacture their principal occupation, when it is no more difficult to understand than is drawing water from a well in "the old oaken bucket."

Many rotative engines do as good duty as the best Cornish Engines, and the pump-work should be constructed on the same principle for all kinds; but many a man undertakes to design engines before he can sketch a windlass properly.

The simplest and cheapest way to pump water is, to force some perfectly smooth substance, without appreciable pores, into the body of water, so that the water may rise a corresponding amount and flow away. Here we have no friction, no leaks, and, therefore, no loss of efficiency. All the power is utilized. When we add a casing or working barrel with packing, we add friction; when we add valves, we add the work of forcing them open; when we add receiving and delivery pipes, we add friction; when we add turns, we add obstructions; when we contract the pipes or valves, we add thousands of smaller obstructions, and increase the friction, as the square of the speed of the water through the pipes must increase; and when the valves are lifted, they take time to get down again, and water must leak back. The valves and packing will leak at other times, unless they are carefully attended to.

In "Smith's Mechanics" I find the following statement: a pipe of 12 inches diameter, 2,340 fathoms in length, with a head of 20 feet, discharged $\frac{1}{19}$th of that which would have been obtained from a simple orifice of the same diameter. Cornish pumps, well designed, have large pipes; the length is governed by the depth of mine.

Plungers have been packed so tight as to heat the metal and vaporize the water around it. The receiving valve could not lift, and the pump did not work. Cornish pumps are packed with soft, elastic hemp packing, or the best substitute at hand, and the cup of the gland is kept full of some fluid lubricating matter.

The valves or clacks of the Cornish pumps are made of large diameter and small lift; they shut quickly, and the leak back through them is correspondingly small. The stroke of the plunger is always long, and the times of leaking back are thereby lessened.

There is but one turn in the Cornish pumps—that from the plunger-case to the column. The difference of velocity before and after impinging will be a measure of the loss. A 600-pounder cannon shot will pierce a 10-inch wrought-iron plate; but in about a foot, the velocity is reduced from about 1,800 feet per second to no speed at all. Were it fired along the face of the plate, it would be retarded only by friction and air, and would go five or six miles. One foot to five miles, and all owing to obstructions. Water, moving through pipes, acts in exactly the same way.

The above reasons, together with the fact that the attendants are guided by them in taking care of the machinery, explain the superiority of the *Cornish Pumps.*

There is nothing peculiar in the Cornish boiler, but it is put into its place with the knowledge that there is a certain amount of heat to be developed by the perfect combustion of the coal, and with the determination to utilize as much as possible of it. The grate-surface is large, the fire burns slowly, the gases have time to generate and mix with oxygen, and the combustion is almost perfect. In this way, for the same heat developed, a smaller amount of coal is burned than in ordinary furnaces. The boiler is completely enveloped in flues, the heating-surface is correspondingly great, and all the heat is absorbed by the water, except what is necessary for draft, or the little that is conducted away by the thick brick walls. These walls are very cool outside, and the draft is only sufficient to burn the coals slowly, so there is little or no heat lost.

The size of the boiler is regulated by the fact that a steam engine is to be driven—not a hydraulic jack. Water has a free passage to the hot plates, and steam has an equally free passage away from them and straight up through the water; not, as is very often the case in other boilers, along the faces of the hot sheets, keeping the water away. Then the boiler is made large enough for the engine;

there is no violent rush of steam, carrying water with it, into the cylinder at one time and perfect exhaustion at another. Everything is quiet, calm, regular; the steam is dry, somewhat superheated by the upper flues, and passes unobstructed, without any sound, through a large, short pipe to the engine; and these are the causes of economy in the *Cornish boiler.*

A large valve, with small lift, opens quickly, and the full boiler pressure is at once thrown upon the piston. The effect, it is generally conceded, of a load suddenly applied, is nearly twice what it is when very slowly applied, and we have the full benefit of it here. The too ready use of the governor, where the load is steady, is unmistakably wrong; the position of the cut-off should be changed, if the steam pressure varies.

Expansion is carried to the fullest economical extent, in the circumstances. Steam condensed in expansion, or in the pipe by radiation, and water carried over by steam from the boiler, if it ever is, is re-vaporized by heat from the jacket when the temperature of the steam in the cylinder falls below that in the jacket.

The condenser is made especially to condense the steam, and the sooner it gets there, after it has done its work in the cylinder, the better.

The exhaust-pipe should be large, but short, and clothed so that the passage of steam may not be retarded by cold. It is no more a condenser than the steam-pipe is a generator.

The injection should enter the condenser above the steam, and above a scattering plate; this plate will break the large body of water into small parts, and give it a better opportunity to mix intimately with the steam. Condensation will then be more rapid.

The condenser should not be used as a reservoir, and the air-pumps should be situated low enough to take nearly all the water out of the condenser; the channel-plate will then remain full, and the foot-valve cool. Experience is the best measure of the size of condenser and air-pump; but the former should not be too large, nor the latter too small.

Every joint in the engine should be perfectly tight; and, if the air-bucket brings the water against the delivery-valve with a shock, a small pipe, with a check-valve opening inward, may be led into the upper part of the pump, when all the noise in that part of the engine will cease.

All these things apply as well to the rotative engine as the Cor-

nish; but the latter class, especially those of the Bull engine type, have less rubbing surface than any other. An idea of how much less, may be formed by the following comparison. The Bull engine stands directly over the shaft; the rubbing surfaces are the piston and the piston-rod stuffing-box. Guides are seldom necessary.

The rotative has, in addition to the above, the crank-pin, two journals, bearing, perhaps, a forty ton wheel, the guides, and all connections leading to the shaft. One system of valve-gearing may balance another; but, generally, the Cornish gear is easiest worked. If we tighten the crank-pin brasses a little too much, the pin is, perhaps, red-hot in ten minutes. If we tighten the crank-shaft brasses a little too much, the engine may stop in ten minutes. I have seen these things occur.

Steam in the steam stuffing-boxes, good packing, oil in the gland-cups, the least possible obstruction to the passage of water and steam, and smooth, well lubricated bearing surfaces, go to make the superiority of this machine.

The secrets of the success of the Cornish engineer are these: He has certain work to be done. He has certain power to do it. He makes and keeps a clear track. He applies *all* the power given into his hand. He knows, too, that pumping water is a simple, straightforward business, and he goes about it in a simple, straightforward way. Commencing with the study of first principles, he produces an effective machine.

Most Cornish engineers can do little else than make a good pumping engine, but they do that well. The man that can make a good rotative engine *understandingly*, will not fail to make a good Cornish engine.

As, in Cornwall, fuel is very expensive, and mines are very deep—several over four hundred fathoms—the greatest care is necessary to make them pay, and were the engines badly designed and constructed, or carelessly managed—were the coal wasted in bad firing, leaks or unnecessary friction, as in many of our rotative engines—the duty would soon come down, and the high reputation now enjoyed by the Cornish mining engineer, and his pumping engine, would be heard of no more.

And these are the causes of superiority of the *Cornish Pumping Engine.*

ON THE INFLUENCE OF ARTIFICIAL ILLUMINATION ON THE QUALITY OF THE AIR IN DWELLING-HOUSES.

Translated from the German of a paper of Dr. Gorup-Besanez, and read before the Polytechnic Association in New York, December 26, 1867.

By Dr. Adolph Ott.

The respiratory exhalations of man, and the products of combustion, generated by the various contrivances for artificial illumination, are to be regarded as the chief causes of the unhealthy condition of the air in dwelling-houses, these being an abundant source of carbonic acid gas. Mr. Pettenkofer, the learned savant of Munich, in investigating to what degree the air in dwelling-houses may be charged with this gas, showed that its quantity may serve us as an indicator of the impurity of air, though it is not the only and perhaps not the prevalent cause of bad air, as other changes of the atmosphere (as those produced by organic vapors), are nearly always proportional to the increase of carbonic acid gas. Or, the increase of this gas may indicate how many times a certain quantity of air has been subjected to the respiratory actions of the lungs and bodies, of a certain number of individuals.

The various contrivances for artificial light also exert an injurious influence on the quality of the air in dwelling-houses, which is the worse, the brighter the illumination or the greater the disproportion between the number of flames and the size of the room which is illuminated, and its state of ventilation. As well understood, however, as this may be, it appears that no experiments have been made as to the value which this factor may reach under different circumstances. Dumas only states the important fact, that in gas illumination, both the consumption of oxygen and the production of carbonic acid is very considerable. The question, however, whether the quantity of carbonic acid of an artificially illuminated room can be considered as an indicator for the impure condition of the air, must be investigated further. It cannot be denied that Pettenkofer's statement cannot be applied directly for artificial illumination.

The little that it offers, is strong grounds to search for the prevalent cause of the vitiated condition of the atmosphere of a room in its amount of carbonic acid, but with even less reason can this be adopted for artificial illumination, as it is just in this case that the

imperfect products of combustion are to be considered in their hygienical effects. While on one hand, we may admit with safety, that in an impure air, caused by the respiratory and perspiratory exhalations of man, the increase of other organic gases are proportional to the increase of carbonic acid gas, this does not seem to hold true in the case of artificial illumination; nay, it appears (according to the theory of combustion), as if the quantity of carbonic acid gas and that of the gaseous products of imperfect combustion were inversely proportional to each other. This certainly would be so, if we were able to produce perfect combustion, but it is a well demonstrated fact that in ordinary illuminating flames, perfect combustion does not occur. Perfect and imperfect products of combustion must, therefore, be in a nearly invariable proportion to each other, and the more illuminating material is consumed, the more carbonic acid, carburetted hydrogen and oxide of carbon will be generated. The amount of carbonic acid will therefore give us always a measure for the whole quantity of the combustion products mingling with the atmosphere in artificial illumination. Experiments in this direction have been made in Germany, by the very able chemist, *Dr. Zoch*. He has also made a series of determinations on the increase of carbonic acid in lighting a room of a known capacity with gas, petroleum and rape-seed oil. Consumption of the lighting material, time and intensity of light, were self-evidently taken into account. The room in which those experiments were made, was of a capacity of 2,540 cubic feet; it had two large windows, one door being opposite, with two blank walls, the third being at the corridor. The building material was good, dry sand-stone. During the experiments, the room was either not, or only momentarily, entered.

Gas illumination was performed by the flame of a common soapstone burner. The gas was coal gas of good quality, and the consumption reached five cubic feet per hour, the illuminating power being equal to ten and a half normal flames (one normal flame being equal to that of a stearine candle weighing a quarter pound).

Petroleum illumination was performed by a common kerosene lamp, with burner; it gave a bright light without smoke. The spec. grav. of the rectified petroleum was 0·805, the consumption 231 grains per hour, and the illuminating effect equal to three and a half normal flames.

The rape-seed oil illumination was performed by a "moderator"

lamp, with round burner. The consumption was equal to 470 grains of oil per hour, the lighting effect being equal to four and a half normal flames.

The photometric measurements were performed by Bunsen's photometer, the carbonic acid was determined by Pettenkofer's method, with a solution of baryta and oxalic acid. One determination was made before the experiment, and the other after its conclusion. From these trials, it was very soon discovered that the increase of carbonic acid in burning one and the same flame, was

FIRST SERIES OF EXPERIMENTS—GAS ILLUMINATION.

Determination of the increase of carbonic acid in burning a gas flame = 10½ normal flames.

By Dr. Zoch.

The experiments were conducted in a room with closed double windows, in April, 1866.

Burning time.	Gas consumption in cubic feet.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.	Remarks.
		Before combustion.	After combustion.		
47 min.	4	0·553	1·447	0 894	
47 "	4	0·655	1·466	0·811	
48 "	4	0·543	1·405	0·862	
48 "	4	0·560	1·443	0·883	
48 "	4	0·555	1·395	0·840	Heavy rain, during previous night.
49 "	4	0·736	1·570	0·834	
1 h. 40 "	8	0·334	2·249	1·915	
1 h. 55 "	8	0·512	2·343	1·831	
1 h. 56 "	8	0·636	2·315	1·679	
4 h.	20	0·647	2·954	2·307	

becoming smaller for every following period of time, as natural ventilation was setting in. The trials were therefore continued with each illuminating material until the increase of carbonic acid gas had reached its maximum. The results of Dr. Zoch seem to me not to be without interest, and well adapted to fill a void hitherto existing, and this may justify their publication.

These determinations being made with double windows, it seemed not to be without interest, to repeat them with single windows, in order to perceive the changes contrasted with natural ventilation. The results communicated in the following table, prove that this influence was very small.

THE EXPERIMENTS WERE CONDUCTED IN APRIL AND MAY, 1866.

EXPERIMENTER, DR. ZOCH.

Burning time.	Gas consumption in cubic feet.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.	Remarks.
		Before combustion.	After combustion.		
48 min.	4	0·643	1·496	0·853	
48 "	4	0·625	1·432	0·807	
49 "	4	0·624	1·372	0·748	Very windy.
52 "	4	0·818	1·684	0·866	
1 h. 43 "	8	0·798	2·412	1·619	
1 h. 45 "	8	0·391	2·043	1·652	Rain.
1 h. 46 "	8	0·534	2·216	1·682	Heavy wind.
1 h. 30 "	12	0·487	2·389	1·842	
2 h. 32 "	12	0·685	2·569	1·884	
4 h.	20	0·642	2·906	2·264	

From these experiments, we learn the interesting fact, that in burning a single gas flame in an ordinary sized room for several hours, the amount of carbonic acid of the atmosphere may reach three parts per thousand, viz: a quantity only to be met with in hospitals, prisons and garrisons, where the process of respiration of many individuals is going on. Even the burning of a gas flame during the time of forty-eight minutes, with the small gas consumption of four cubic feet, is sufficient to produce a quantity of carbonic acid gas, which is twice as great as that of the atmospheric air. It may also be seen that the increase of carbonic acid gas remains approximatively the same for equal times and at different observations, while it does not increase proportionally for a longer time, as then natural ventilation is constantly becoming more effective. These circumstances explain the above figures so well, that further discussion appears superfluous.

SECOND SERIES OF EXPERIMENTS—PETROLEUM ILLUMINATION.

Determinations of the increase of carbonic acid in burning a kerosene lamp. Lighting effect = 3½ normal flames.

EXPERIMENTER, DR. ZOCH.

Burning time.	Kerosene consumption in grains.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.
		Before comb.	After comb.	
1 h.	235·33	0·593	1·072	0·479
1 h.	235·33	0·550	0.975	0·425
2 h.	470·61	0·786	1·438	0·652
2 h.	470·61	0·675	1·440	0·765
3 h.	705·15	0·606	1·441	0·865
4 h.	944·31	0·697	1·577	0·880

In burning a kerosene lamp, the production of carbonic acid gas is considerably less than in burning a gas flame; the numbers, however, cannot be directly compared, since they are not reduced to the same lighting effect. We shall see, that in this case, kerosene

illumination generates even more carbonic acid gas than does gas illumination.

THIRD SERIES OF EXPERIMENTS—RAPE-SEED OIL ILLUMINATION.

Determination of the increase of carbonic acid in burning a "moderator" lamp with Argand-burner. Lighting effect = 4½ normal flames.

EXPERIMENTER, DR. ZOCH.

Burning time.	Rape-seed oil consumption in grains.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.
		Before comb.	After comb.	
1 h.	416·61	0·908*	1·244	0·336
2 h.	941·23	0·513	1·162	0·649
3 h.	1,296·12	0·623	1·367	0·744
4 h.	1,829·74	0·769	1·537	0·768

As seen from this table, rape-seed oil illumination generates the smallest amount of carbonic acid gas, although the "moderator" lamp has a greater lighting effect when compared with the small kerosene lamp, and notwithstanding the greater consumption of oil by the latter. After four hours, the quantity of carbonic acid in the room amounted to 1·537 per thousand, that is, only half as much as generated by an ordinary gas flame during the same time. From these experiments, it is obvious that we procure pure and brilliant light of gas illumination at the expense of pure atmosphere.

The numbers communicated in the foregoing tables can, however, not be *directly* compared with each other, they being not reduced to the same lighting effect. We have done this in the following table, where the increase of carbonic acid in the three modes of illumination is calculated for the space of 100 cubic metres (130·8 cubic yards), and upon a lighting effect of ten normal flames, at the time of one, two, three and four hours.

* This amount of CO_2 is to be accounted for by the presence of many individuals in the room previous to the experiment.

Burning time.	Increase of CO_2 per thousand.		
	For kerosene.	For gas.	For rape-seed oil.
1 h.	0·929	0·708	0·537
2 h.	1·456	1·342	1·038
3 h.	1·779	1·513	1·190
4 h.	1·811	1·562	1·229

These experiments allow some important conclusions. First, we see that kerosene yields more carbonic acid gas than street gas, and the latter more than oil; in accordance therewith, Dr. Zoch observed that in kerosene illumination the atmosphere was more vitiated when the amount of carbonic acid had reached 1·779 per thousand, a phenomenon not at all observable in rape-seed oil illumination, and in a scarcely perceivable degree in gas lighting. As we cannot possibly believe that the carbonic acid alone is the cause of this impurity, we have to account for it in the products of imperfect combustion, and hence we obtain another argument for the hypothesis, that the amount of carbonic acid generated in illumination may be taken as an indicator for the other changes in the air. A delicate nose detects in petroleum illumination very soon the products of imperfect combustion. The foregoing numbers also show us that for the three modes of illumination, a maximum in the production of carbonic acid gas is reached after three hours.

Though it may seem presumptive to generalize conclusions from the above numbers, they nevertheless seem to be useful in the formation of hygienic postulates. They firstly prove the excellency of good rape-seed oil illumination, which charges the air the least with extraneous impurities. Of no great practical importance is it that kerosene contributes most to vitiate the air, as this mode of lighting is not very general, but it is a very different affair with gas illumination. Who has not noticed of late years in the illumination of the stores, theatres, concert and political halls of our great cities the fact that each attempts to rival his neighbor in the glaring effect of gas light, but at the same time, who has not also made the observation that the greater the light, the greater the oppressiveness and vitiation of the atmosphere? We are of the opinion that this sen-

sation of discomfort is partly to be attributed to the radiant heat, also an effect of gas illumination. Briguet, a French physicist, has found that a gas burner, consuming 4·87 cubic feet per hour, heats 1·74 cubic yards of air from 32° to 212° F. At a distance of one foot from a gas flame of 1·14 inches diameter, which was surrounded by a glass cylinder, the thermometer rose 3·6 degrees, but at a distance of only 6·3 inches, not less than 10·8 degrees. Another source of this discomfort, however, is undoubtedly and even in a well ventilated room, the vitiation of the air spoken of. Individuals who are compelled to remain in a brightly illuminated room for some time, complain soon of impediment in breathing, a dry heat in the throat, a tickling sensation in the larynx, dry and fatiguing cough. With people of weak chests and tuberculous constitution, this kind of atmosphere agrees least. To ascribe those symptoms to the effect of heat alone, would certainly be unjustifiable.

There are many unfounded prejudices against the use of gas in private houses; for small rooms with imperfect ventilation, this mode of lighting is undoubtedly not well adapted, and all the disadvantages noticed will appear in a higher degree; I doubt, however, very much, if those accustomed to the bright light and convenience of gas illumination, will be induced by such suppositions to quit the use of so very comfortable an article, before ill health has been the punishment for the neglect. Whether the atmosphere of a room when it is charged with three per thousand of CO_2 in consequence of artificial illumination, will have the same effects as an air vitiated to the same degree with this gas by respiration and perspiration, and whether the other products hereby generated are of equal effect, is a question yet to be decided, but worthy of consideration.

Electro-Plating Iron with copper and brass. The process so successfully carried out in France for this purpose, has been recently published, and is very simple. The iron object is coated with a varnish of resin, dissolved in benzine. This is then coated with plumbago, as in electro-plating non-metallic bodies, and the copper then deposited as usual. Iron, as all know, takes a light coat of copper with singular ease, by electric decomposition or chemical substitution; but as soon as any effort is made to thicken this layer, it peels off. To overcome this difficulty, has hitherto defied the ingenuity of many experimenters, but the question has at last received the curious practical solution above noticed.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

By Prof. Henry Morton, Ph. D.

(Continued from page 203.)

In order to illustrate and bring vividly before your minds some of the strange conditions which we have found to exist on the moon's surface, I have caused to be prepared and now bring by a signal upon the screen, a series of imaginary views of lunar scenery, which are intended to represent, as well as may be, what would appear to one could he place himself upon our satelite, and in that desolate, sun-scorched, airless, and therefore soundless as well as lifeless solitude, look about him and observe the objects by which he was surrounded.

The first of these pictures which I bring before you, is a view of the vast expanse known as the Mare Imbrium, or Sea of Showers, seen from the spurs of the Apennine range, which skirts its south-eastern boundary, and looking towards the north, where the lunar Alps wall-in the plain, and terminate the view.

From the foreground in this picture, Plate IV., to the most distant object, is a space of 500 miles, so that even at the outset we must make an effort of the imagination to grasp such a stretch of view, as was never seen by human eye. In the foreground, to the extreme right, are seen two volcanic craters; the nearer of these is called Autolycus (42 Pl. II)., and the further, with a central cone, Aristillus (43). A little to the left of these, is seen the grand volcanic ring of Archimedes (41), which is fifty miles in diameter and about one mile in height.

From the midst of the plain, but nearer to its further border, rises an abrupt pinnacle of rock, known as Pico, 7,000 feet high above the surrounding plain, and casting a shadow, which, like that of

THE ALPS AND MARE IMBRIUM.

Mount Athos, noticed by Plutarch as reaching to Lemnos, stretches for miles outward from its base.*

In the distance is seen the range of the Alps, which by its angularity and abruptness of ascent, bears evidence to the absence of all those softening and leveling influences of air and water, which have rounded the sharp outlines and crumbled down the abrupt surfaces of our terrestrial ranges. To the left, and setting somewhat back among the Alpine peaks, we see the rugged flanks of Mount Plato, a volcanic ring without any interior cone. Near the extreme left of the picture,† we see one of the smaller volcanoes, Timocharis, whose crater is but about eighteen miles in diameter, and a little to the right of this and more in the foreground, is one of those sunken craters or volcanic wells which are encountered in almost all parts of the lunar surface. In fact, careful measurement shows us that many of the large craters have their interior plains depressed considerably below the surrounding surface of the planet. Thus, Eratosthenes (38), which terminates the Apennine chain to the west, while lifting its exterior ring 3,000 feet above the plain of the Mare Imbrium, has its interior level surface 3,000 below the same level, or 6,000 feet beneath the exterior ridge, the rocks falling on the interior, in a vertical precipice, to meet the inner plain, from the centre of which a conical peak towers up, *not* in the *air*, but towards the sky.

Another feature in this view, worthy of remark, is the black sky studded with stars, overhanging a scene brilliantly illuminated by the sun. This is, however, we have every reason to believe, true to nature; for, as we know, the light reflected from our sky is due to the presence of watery particles suspended in the air, and scattering the impinging sun-rays in all directions; and as there is no atmosphere and no water in the moon, no such action can there take place, but the sun's rays must proceed undeflected in straight lines to the surface of the planet, and thus fail to produce any such diffused illumination; so that the sun itself would appear as a disk

* Mount Athos, on the coast of Macedonia, rises abruptly from the sea to a height of 6,349 feet, and according to the statement of Pierre Beleu (quoted in the Cosmos by Humboldt), that "its shadow reaches to the broken figure of a cow in the market place of Mycene," must thus extend its wand of shade over the Mediterranean for thirty miles.

† For several ideas embodied in this picture, and many other valuable suggestions, we are indebted to a little work entitled "The Lunar World," by the Rev. J. Crampton, Edinburgh.

of intense brightness, set in a sky dark as that of our blackest midnight, and sprinkled with the larger stars, the eye being rendered incapable of perceiving the smaller ones by the glare of nearer objects.

We now bring upon the screen another illustration of lunar scenery, which we might, by analogy, call a moonlight view; this being a case wherein the revealing light comes, not directly from the sun, but only as reflected from the illuminated face of a planet. In this case, the earth acts as a moon to her own moon. That light is in fact so reflected by the earth, and does so illuminate the moon, we know by actual observation; for the light by which at new moon we often see the entire disk of our satellite faintly shown, is simply that received from the earth at that time, presenting an almost "full face" to the moon. The phenomenon to which I refer is that called by us in common and ideal language, "the old moon in the new moon's lap," or by the French, "la lune cendre" (the ash-colored moon).

That this doubly reflected light should be very faint when at last it reaches our eyes, will appear natural, when we remember that the full moonlight is but $\frac{1}{100000}$th of that received from the sun, and that, therefore, received by the second reflection, must be again decreased in a somewhat similar proportion.

The picture now before us (see Plate I., facing page 59), represents the volcano Copernicus, which formed a conspicuous object in most of our lunar photographs (see Pl. II)., and which rises from the northern region of the Mare Nubium, on the southern flank of the Karpathean mountains, which form a prolongation of the Apennines towards the west, and separate the Seas of Showers and of Clouds (Mare Imbrium and Mare Nubium).

The scene here represented, is that which we may suppose would appear to a spectator looking southward from the summits of the Karpathean mountains, over the rugged ground of the Mare Nubium, and with the craters of Eratosthenes and Stadius to the left. To illuminate this desolate region, we have the subdued light of a "full earth," which, though in area sixteen times larger than our moon, would, it is probable, by no means reflect an equally increased proportion of light, since the vast surfaces of water and of vegetation would be far inferior in reflecting power, to the volcanic lava and glittering rock which compose exclusively the lunar surface.

On the "earth-moon" is seen in the picture an indication of the American continents and Pacific ocean, as also certain parallel cloud-bands, such as we also see on the planet Jupiter, and which would doubtless be produced by the action of our trade winds.

This picture is photographed from a painting made by Mr. James Hamilton, expressly for the purpose, together with other views which we shall see and discuss presently, and conveys in an admirable manner the idea of vastness and desolation, which must be the characteristic of such a scene.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst, Troy, N. Y.

(Concluded from page 212.)

Among the more specific "ideas of reason," "first truths," "intuitions," are those of time, space, personal identity, objective reality of sensible objects, and causes as required by existing effects.

Here it is to be remembered, what is not often expressly stated, that man's finiteness finds limitations to its *beginnings* as well as to its advance. That is, there are fundamental ideas as starting points of all thought, *back of which* we cannot go any more than we can go *forward* beyond a certain point.

But to return, under, and in certain important respects, subject to the supreme powers, reason and will, are ranged the *working faculties of the understanding*, and the *enlivening*, *prompting* and *motive powers*, called the *sensibilities*.

These working faculties may be known as the

Powers Representative.

Conception = the forming of an *idea* = the mental representative of a *fact*, of the *real*.
- From *perception* = the impressions made on the mind through the senses.
- From *consciousness* = the impression made on the mind by its own working.

Imagination = the representation of the *ideal*.

Memory.—The Reflective Power.

Abstraction = the elimination of the attributes of things, for separate contemplation, and as a basis for comparison, classification, and generalization.
Judgment = the affirmation or denial of agreement between two particulars.
Reasoning = the derivation of one judgment from another.

The sensibilities are generally known as—

The Emotions of
- Cheerfulness or melancholy.
- Joy or grief.
- Love or hatred.
- Honor or shame.
- Etc.
- Anger.
- Terror.
- Surprise.
- Etc.

Desires of
- Property.
- Knowledge.
- Position.
- Power.
- Approbation.

Affections for
- Home.
- Country.
- Mankind.
- Friends.
- Etc.

Coming now to applications, after delays which we hope have not unreasonably taxed the reader: The *nature and relations of good*, and the *structure of the human mind*, as just outlined, on the one hand, and the *demands of civilized life* upon all who share it, on the other, are the *facts* to be regarded in organizing and administering an institution of learning, either general or technical.

In the personal and material composition of an institution, and of its course of study, the full idea of *good* is to be realized to the utmost within the limits afforded by the scope of the institution: so that for example, as *a cardinal principle*, the *whole being* and not merely the *technical knowledge* of the teacher should be favorably brought to bear upon the *entire* life of the student, as well as primarily and mainly upon his attainment of the knowledge-qualifications for his chosen pursuit.

An institution thus becomes a unit, though a compound one, and almost a truly personal one, through the vigor of the co-operating life which fills it. It thus has a life and individuality of its own, and this life should be full of *beauty* as the charming surety that, in its essence, it is good.

The institution should be devoted to *truth*, in its promises and performances, in every direction, by every one; without even momentary pleasure in either offering or accepting appearance for reality, or the work of any other for that to be done by each one's proper self.

And in its means and methods, economy, time and labor should be sought so as to accomplish results at once most real, most valuable, and most enduring, with the least obstruction from imperfect arrangements, inadequate means, or unskillful methods. Thus will the idea of *right* be secured; not merely to attain a proposed end most *truly*, but most easily, readily and efficiently.

The possession of all these invaluable characteristics, even par-

tially obtainable only by costly effort, is the incommunicable secret of every institution, as well as person, that has them.

Taking up next the bearings of the mental structure upon the conduct of an institution, the joint culture of the will and the reason, as they have been defined, should be secured by provisions at once liberal and justly regulated, for their exercise. Perhaps this can in no way be better accomplished, having regard also to the cardinal doctrine of the perfect unity, though a complex one of the institution, than by delegating the regulation of various details of administration and usage to class organization, with the reservation of an advisory and, ultimately, of course, of a veto power. Such a course appears as the happy mean between the irksome restraint of an authoritative code, so minute as to leave nothing to be done freely, and a looseness which relies on nothing more than previous social good breeding, the pervasive influence of general surrounding civilization, and prevalent youthful instincts of deference to its legitimate guardians and teachers, as guarantees of good behavior.

Experience, moreover, of the extent to which even these guarantees can be relied on, gives happy promise of the best results from the strong added appeal to regard for honor, and reputation for good judgment, contained in the course here proposed. Experience further shows, too, how carefully older judgments are consulted by youth when placed in the simplest positions of responsibility in matters in which they feel a pure enthusiasm. So that in this method of admitting them to an appropriate share of the work of conducting affairs, we find realized the natural idea of younger judgments exercising themselves in happy and invigorating freedom, within certain limits of fundamental principle, established by those of greater and more studious experience.

A capital omission, however, would exist if no reference were here made to one point, requiring special attention in the authoritative oversight of the main features of principle and practice incorporated in student organizations, so far as these directly affect the rights and powers of an institution, and of its members in their individual capacity. Youth is usually ardent in its enthusiasms to a degree which often becomes passionate, and that, too, sometimes, irrespective of the real importance of the question at issue. As soon as passion sets in, opposition, however, conscientious in principle, courteous in manner, and justly defensive of innocent personal rights, is too apt to be visited with abuse which is both tyrannical

in spirit, and odious in expression. Of course, the noblest resistance to such abuse is a moral strength against which the *strength* of *passion*—which is the *weakness* of the *person*—dashes itself in vain. But virtue, modest in its immaturity, in a minority, and unsupported where it has most right to look for effectual support, must not be unjustly taxed with excessive demands upon it. Those having both the power and the right to sustain it should do so, and as prevention is better than cure, this should, and, as experience shows, can be accomplished in the manner proposed, viz: by securing the adoption by class organizations, wherever these are allowed to exist, of certain provisions as guarantees of due recognition of the ultimate authority of the institution, and of the personal rights of its members.

Or, to repeat, in the negative form, owing to the importance of the subject, everything should be excluded from the rules and practices of student organizations which could naturally tend to occasion or to intensify differences between officers and members of the institution or embarrass the settlement.

The same end here discussed, of training the will in connection with the reason, may further be promoted by fostering all those less hazardous organizations whose object is the culture of some improving art or manly sport, rather than the assertion and exercise of personal influence, in matters of general administration. Moreover, if instructors sincerely aid and sympathize with such organizations,—musical, boating, literary, or scientific,—the idea of unity is as well expressed as in the former case. But the agencies through which it is expressed being so different in the two cases, the employment of both is necessary to the most intimate union of all interests, and is therefore worthy of the superior thought, patience, care, and—to tell the whole—love necessary in attaining this ideal union.

Finally, in attaining this end, the whole range and compass of the sensibilities must be known and skillfully handled, as are those of a great organ. But this opens up to thought a vision of harmonies or discords of being and living as numberless as the combinations of audible harmony. Wherefore we stop at once, and trust to present the promised curriculum in another article.

Williamstown, July, 1868.

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 210.)

On the contrary, when persons think they are able to earn their own living and a little more, the more pure air they breathe, provided they have an abundance of good wholesome food and plenty of exercise, the greater amount of physical or mental labor they can perform.

The pecuniary nature of health is but imperfectly understood. It was found in England that when a certain portion of the tenement houses, belonging to some of the large factories were well ventilated that the tenants required more food, it cost them more per week to live and supply themselves and families with the necessaries of life.

They consequently could not work so cheap from week to week as those living in *un*-ventilated houses. This appeared on its face to be a strong argument against the pecuniary value of ventilation. But let us take a more careful view of this. Every animal or machine has its market value—a horse is worth so much in the market, so is an ox and a sheep, and to our great shame we have until very lately had a regular market price for a man and a woman. Now, owing to even the little intelligence which it was formerly admitted that a slave had over a horse, we would give four or five times as much for a man as for a horse.

A good man before the war was worth from twelve to fifteen hundred dollars, and some two thousand.

The superior intelligence and energy of any one here, and the greatly enhanced prices since the war, in connection with the fact that one man with brains can manage machinery that is sufficient to do the labor of twenty horses, adds greatly to the value of an intelligent man,—or, in other words, any manufacturer or capitalist would be very willing to give $5000 for the services for life of any intelligent, able-bodied man between the ages of twenty and thirty years, taking all the risks of his living, and clothing and feeding him for life.

Now, that $5000 is the entire capital of many young men, sup-

pose a large manufacturer wants hands at piece-work, and this young man, say, is just married, and anxious to get along, takes the work just as low as he possibly can, he finds by saving a little in his food, and by keeping his house shut up tight, with an air-tight coal stove he can save coal, and thus at the end of the week can just make both ends meet, or, in other words, can pay expenses.

Now he does not calculate how much of his original $5000 he put into that work for the capitalist—but by the reduction of his physical strength he has used a shilling's worth a day of that capital; six shillings a week, twenty-four shillings a month, and so on.

Thus drop by drop does that wealthy capitalist absorb the very life blood. Ounce by ounce are the sinews of this poor man bartered away and appropriated by the capitalist.

He is daily growing weaker as his family cares increase, and in a few years, with a wife and family of small children entirely dependent on his daily labor for their food, clothing and schooling, he finds himself broken down in health with a ruined constitution, and he is then cast aside for another, younger and more vigorous man, who will engage to work cheaper, and can afford to do so by using a shilling's worth daily of his $5000 capital the same as his predecessor.

This arises from the ignorance of these laboring people of the true value of health and of the proper means of preserving it. What is the result.

A nation of unhealthy people must inevitably become a nation of paupers, but a healthy nation will surely become a wealthy nation.

For a proof of this assertion we have only to look to the manufacturing districts of England, as they are amongst the most unhealthy. Could they support themselves if their trade with foreign and newer countries was cut off? Undoubtedly not. And look at New England, what does the census of her manufacturing states give? A very small increase of population indeed.

And the manufacturing wards of this city, too, will show a greater amount of ill health and pauperism, which always go together, than the non-manufacturing districts.

Now, how can this be remedied—by any simple act of legislalation? I answer no! Not even the fiat of that Supreme Congress now gathered under our beautiful flag, representing as it does the most powerful nation on the face of the earth, could reconstruct

society in this respect. No, you must teach the people, the laboring man, the bone and sinew of the nation, the value of health and how preserve it. The parents then will be but in the prime of life when their children shall have grown to manhood, and they in their turn will be competent to care for their parents in old age.

I want each of you to become a lecturer on ventilation; I do not mean merely to give three or four lectures in a whole year—but to lecture every day of your lives, because there is not one of you here but what has some friend now suffering for the want of pure air.

I want you, too, to go to the home of the laborer, the man that is not here to-night—he whose laborious toil from early morn to dewy eve, demands rest in the evening, instead of allowing him the privilege of attending lectures.

I have visited many such, and find that a few simple, kindly words of explanation are always gladly received, and frequently have their good effect in inducing them to remove a fire-board in a sick-room, or by putting on an extra blanket, to allow the windows to be opened a little more every night, and thus do a great kindness to these poor, worthy people, by getting two cubic feet of pure air to enter, where but one entered before.

Could Philadelphians but be fully aroused to the great importance of this thing, the mortality of this beautiful city might be reduced for the year 1868, perhaps even more than it was for the year 1867, because I believe there is no city on the face of the earth so favorably situated for an immediate reformation in this respect as this city, as all the houses are built so isolated, with a window and fire-place in nearly every room: while in New York one-half of the population live in houses of entirely different construction, nearly half the sleeping-rooms being merely dark closets into which the purifying rays of the sun and the pure external air can never enter.

And this is a very serious defect, which nothing but tearing down and re-building can fully remedy; although a good artificial ventilation might greatly improve them. Philadelphia has the advantage in this respect, very decidedly.

If it were in any way possible to get all the physicians stirred up, to make some active exertions towards inducing the people to be more careful about the ventilation of their houses, it might have a wonderful effect.

This, however, is hardly to be hoped for, as a regular old school Philadelphia physician is probably about as respectable and proper and conservative a man as the sun shines on. We could scarcely find a greater curiosity than the name of a regular old school Philadelphia physician at the head of a recommendation to public favor of any new thing, no matter of how much public utility it might be.

(To be continued.)

Bibliographical Notices.

Aniline and its Derivatives. A treatise on the manufacture of Aniline and Aniline Colors. By M. Reimann, Ph. D., L. A.M., to which is added, in an appendix, the Report on the Coloring Matters Derived from Coal Tar, shown at the French Exhibition of 1867. By Dr. A. W. Hofmann, F. R. S., M. M. G. de Laire, and Ch. Girard. The whole revised and edited by William Crookes, F. R. S. Published by John Wiley & Son, Astor Place, New York.

In giving to the American public a reprint of this work, its present publishers have filled a vacancy much deplored by all who are in any way interested in the great and daily increasing industry of Aniline Colors, and by all who take an interest in the progress of the age, as shown in its manufacturing improvements and scientific discoveries.

It is now scarcely ten years since the first practical step was made in the direction of this manufacture, and yet it has grown to be one of the first rank among existing processes. By the late discovery, of an aniline green, the gamut of aniline colors has been filled out; and we now have every color of the prismatic scale represented in this admirable material, the increased demand for which is keeping pace with the daily increasing facilities and economy in its manufacture. The present work describes from the beginning and with such full explanation as renders every point plain to any one possessing even a general knowledge of chemistry, each process in manufacture, from the primary benzine to the latest derivative, and by means of numerous illustrations shows the form and propositions of the apparatus employed.

The report on the colors shown at the exhibition is written by Dr. Hofmann with the life and interest which characterize his productions, and is enlivened by many incidents in connection with the history of the subject, which add much to its vivacity.

We can cordially commend this work to all manufacturers and men of science who are interested in its subject.

A Treatise on Optics; or, Light and Sight, theoretically and practically treated with the application to Fine Art and industrial pursuits. By E. Nugent, C. E., (103 illustrations.) Published by D. Van Nostrand, New York: For sale by J. B. Lippincott & Co., Philadelphia.

For a long time nothing has been more needed than a good work on practical optics. Neither in our language nor in any other, we believe, does such a thing exist, as a book which will convey to a reader any notion of the various principles and facts, which are every day applied either ignorantly or with intelligence by all those who are engaged in the construction or use of optical apparatus. We have a sufficiency of optical works, it is true, but these, as a rule, concern themselves with the recondite and unpractical parts of the subject, and while they treat with admirable minuteness and thoroughness of research, such subjects as those of interference and circular polarization, pass over almost in silence the practical problems relating to the correction of the various aberrations of lenses, to the remedy of distortion, and to obtaining the best results under different conditions.

We should, therefore, hail with pleasure the appearance of a work, such as that which is now before us, which though, as its size necessitates, but an essay towards the full treatment of the vast subject it attacks, yet opened the road in the right direction, and in some respects, did its work well. The first part of the book is taken up with the exposition of the general facts, laws and theories of light. The subjects of refraction and reflection are well discussed, and the actions of lenses described, with many convenient rules for the calculation of focal lengths of single lenses; this being, in fact, an abstract of the corresponding part of Brewster's Optics. But we find no notice on the subject of equivalent foci, and the methods requisite for measuring the lengths of compound lenses.

On the subject of dispersion our author seems to live about ten years behind the present age, and gives us the knowledge and theo-

ries of that dark period, with an entire ignoring of the whole subject of spectrum analysis, and all the late discoveries in that direction by Bunsen, Kirchoff, Tyndall, Miller, Stokes and others, which is certainly very extraordinary.

He also propounds a theory of colors which much resembles that of Goethe, and which, though *perhaps* tenable in *his* time, cannot now have a leg left to stand upon, thanks to the spectrum discoveries above noticed.

We observe that Mr. Hunt is frequently quoted, and presume that the author of Elementary Physics, Researches on Light and the Poetry of Science is the authority; but without entering into an elaborate criticism, it will appear, that an author who in illustrating the law of gravitation says:* "If the sun and earth were equidistant from Jupiter, the influence of that planet would be the *same on each and would draw them through the same space in the same time*," cannot be a very safe guide; not to mention that the "Researches on Light" were made nearly twenty years ago, since when the science of Optics has effected the most prodigious advances in facts and theories.

The latter portion of this book, which is taken up with the description of various forms of lenses and optical instruments, contains some things of value, though enriched with copious omissions of almost all American inventions in this direction, and with a little too many of Mr. Dallmeyer's optical combinations, for photographic work.

The Bankers' Magazine for October. Edited by J. Smith Thomas, 41 Pine Street, New York.

This number contains an elaborate article on the past and present production of gold and silver, throughout the world.

I. The production since the discovery of America. II. The production in the Nineteenth century to the year 1848. III. The production since the discovery of gold in California. IV. The present annual production in all countries. V. Annual report of the General Land Office, U. S., on Gold and Silver. VI. Special report of Mr. J. Ross Browne, on the Pacific Gold Region. VII. Special report of Mr. James W. Taylor.—The relative supply of both metals, past and present.—The annual and aggregate supply throughout the world, with the views of Messrs. Jacob, Newmarch and Chevalier and others.

Also a list of 360 Savings Banks in New England and New York, number of depositors and amount of deposits in each.

* Elementary Physics, by Robert Hunt, p. 47.

A COMPARISON *of some of the Meteorological Phenomena of* AUGUST, 1868, *with those of* AUGUST, 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	August, 1868.	August, 1867.	August, for 18 years.
Thermometer—Highest—degree	89·00°	86·00°	97·00°
" date	30th.	14th.	2, '56; 4, '59.
Warmest day—mean	83·00	80·67	88·50
" " date	3d & 30th.	19th.	10th, '63.
Lowest—degree	61·00	59·00	47·00
" date	17th.	1st.	26th, '56.
Coldest day—mean	71·67	67·50	59·00
" " date	17th.	31st.	26th, '56.
Mean daily oscillation	10·65	12·44	14·99
" " range	2·87	3·68	3·65
Means at 7 A. M.	74·26	71·02	71·04
" 2 P. M.	80·90	78·18	81·00
" 9 P. M.	77·37	74·56	74·12
" for the month	77·51	74·59	75·39
Barometer—Highest—inches	30·279	30·210	30·279
" date	28th.	31st.	28th, '68.
Greatest mean daily pressure	30·209	30·128	30·229
" " " date	28th.	26th.	20 & 31, '55.
Lowest—inches	29·627	29·578	29·356
" date	2d.	16th.	20th, '56.
Least mean daily pressure	29·653	29·599	29·388
" " " date	2d.	16th.	20th, '56.
Mean daily range	0·102	0·108	0·096
Means at 7 A. M	30·006	29·967	29·872
" 2 P. M	29·976	29·939	29·843
" 9 P. M	29·986	29·944	29·863
" for the month	29·989	29·950	29·860
Force of Vapor—Greatest—inches	0·843	0·815	1·024
" date	3d.	14th.	1st, '54.
Least—inches	·386	·317	·268
" date	17th.	30th.	Often.
Means at 7 A. M	·620	·602	·586
" 2 P. M	·625	·609	·594
" 9 P. M	·644	·645	·614
" for the month	·630	·619	·598
Relative Humidity—Greatest—per cent	83·0	92·0	100·0
" date	5th.	15th & 22d.	26th, '54.
Least—per cent	39·0	36·0	27·0
" date	14th.	11th & 26th.	1st, '60.
Means at 7 A. M.	72·3	78·7	76·1
" 2 P. M.	58·8	63·4	56·5
" 9 P. M.	67·9	75·2	72·8
" for the month	66·3	72·4	68·5
Clouds—Number of clear days*	4·	9·	9·2
" cloudy days	27·	22·	21·9
Means of sky covered at 7 A. M	66·1 per ct	63·2 per ct	56·8 per ct
" " " 2 P. M	68·7	63·5	61·7
" " " 9 P. M	46·1	44·5	42·0
" " for the month	60·3	57·1	53·5
Rain—Amount—inches	2·55	16·840	4·411
No. of days on which rain fell	10·	15·	10·1
Prevailing Winds—Times in 1000	s 46°44′ w. 271	s 52°26′ E. 094	s 71°31′ w. 125

* Sky one-third or less covered at the hours of observation.